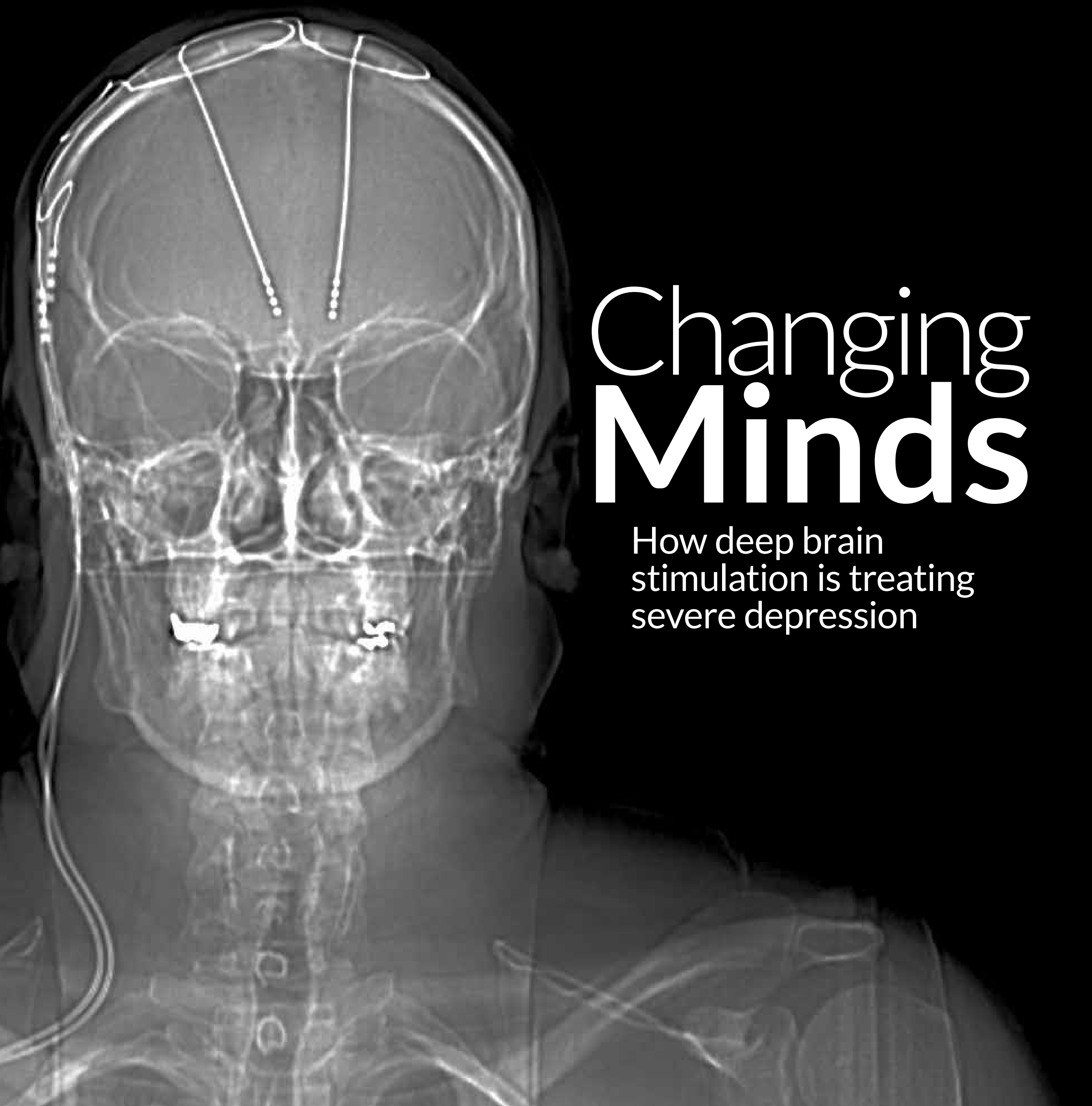
Ancient Humans on the Brink | India's Moon Landing

Science News

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ SEPTEMBER 23, 2023



Changing Minds

How deep brain stimulation is treating severe depression

Thermo Fisher Scientific
Junior Innovators Challenge | A program of Society for Science

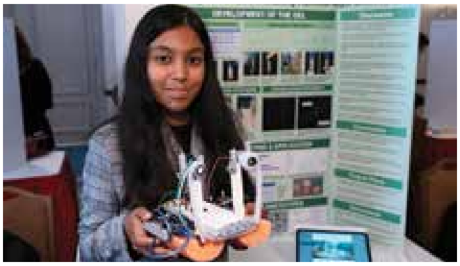
CONGRATULATIONS TOP 300 Junior Innovators!

Thermo Fisher Scientific salutes the 1,828 competitors who entered the 2023 Thermo Fisher JIC. Congratulations to our Top 300 Junior Innovators and good luck to the 30 who will join us as finalists in Washington, D.C. this October!









Nolan Aalto | Omar Abdulaziz | Inika Adapala | Odessa Akervall | Anna Catherine Alcock | Ricky Rex Alexias | Bailey Skeie Anderson | Zakaria Ansari | Cole Aragaki | Jamie Kyle Ashby | Naira Badalyan | Advait Badrish | Ethan Bai | Sanvi Bala | Alya Ban | Adwik Banerjee | Anish Banerjee | Suhani Bansal | Colin Beckner | Emma Beeby | Chase Louis Benedick | Krishna Bhatt | Adyant Bhavsar | Aadi Bhensdadia | Sonia Bohuslav | Ariana S. 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The Thermo Fisher Scientific Junior Innovators Challenge, a program of Society for Science, is the nation's premier science and engineering research competition in the United States, created to inspire sixth, seventh, and eighth grade students to pursue their personal passion for STEM subjects into high school and beyond.

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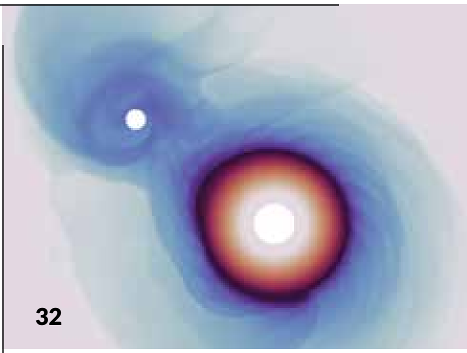
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COVER In this X-ray, electrodes for deep brain stimulation are visible in the head. *The Nash Family Center for Advanced Circuit Therapeutics/Icahn School of Medicine at Mount Sinai*

FROM TOP: KAYLEIGH MCCOLLUM; M. MACLEOD AND A. LOEB/*NATURE ASTRONOMY* 2023; CHRISTOPHER WALTON



Reimagining electricity as a depression treatment

Scientists have known since the 18th century that living beings can generate electricity. By the 19th century, doctors were putting that knowledge to use in medicine.

In 1838, Irish physician Robert Bentley Todd observed an experiment by British scientist Michael Faraday that measured the jolt of an electric eel. Todd went on to apply Faraday's concept of the "electrical force" to his study of the human nervous system.

Todd refuted theories that epilepsy was caused by vascular issues or inflammation. Instead, he posited that it was caused by rapid electrical discharges "exciting the other parts of the brain and spinal cord with all the violence of the discharge from a highly charged Leyden jar," an early type of capacitor. Todd tested his idea by administering electric shocks to rabbits and inducing seizures.

But it wasn't until German psychiatrist Hans Berger developed the electroencephalogram in the 1920s that scientists could observe the brain's electrical activity in action, using small sensors on the scalp to pick up brain waves. At the same time, scientists were exploring the idea of administering electric current to the brain as a treatment. By the 1930s, doctors were using electroconvulsive therapy, or ECT, to treat mental illnesses. ECT is effective, but comes with side effects including memory loss. And it doesn't work for everyone.

Researchers have been working for decades to develop more precise ways to reboot the brain, including implanting electrodes that direct current to specific brain regions. Deep brain stimulation is used to treat Parkinson's and other movement disorders. But as neuroscience and senior writer Laura Sanders reports, scientists are still testing whether deep brain stimulation can also help people with severe depression that hasn't been relieved by medication, ECT or other treatments. She tells the stories of Jon Nelson, a Pennsylvania resident and father of three, and other people who have decided that undergoing brain surgery and living with hardware that constantly stimulates the brain is worth the risk (Page 16). Without it, they say, life was unbearable.

Sanders spent months interviewing scientists and people participating in the experimental treatment. They were generous with their time and candid about their most painful moments. I am so grateful for their willingness to talk with *Science News* and share their experiences with our readers.

In this issue, we also explore a realm far removed from neurotechnology — how culture affects treatment for mental illness. Earlier this year, the American Psychological Association issued an apology to Indigenous peoples in the United States for having supported abusive assimilation efforts and culturally inappropriate mental health treatments, social sciences writer Sujata Gupta reports. That support has exacerbated mental illness, chronic disease, incarceration and suicide in Indigenous communities (Page 14).

"Psychologists need to learn about research methodologies developed by and for Indigenous populations," the APA's report said. Researchers are now collaborating with Indigenous communities to develop treatments and test how to measure progress based on cultural norms. Mental health isn't just a matter of brain waves; it's also a social construct. — *Nancy Shute, Editor in Chief*

Science News
1719 N Street NW, Washington, DC 20036
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Editorial/Letters: feedback@sciencenews.org
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Advertising/Sponsor content: ads@societyforscience.org
Science News (ISSN 0036-8423) is published 22 times per year, bi-weekly except the first week only in May and October and the first and last weeks only in July by the Society for Science & the Public, 1719 N Street, NW, Washington, DC 20036.
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Excerpt from the September 29, 1973 issue of *Science News*

50 YEARS AGO

A step toward fusion

One spur to the development of more powerful lasers is the possibility of using them in projects seeking to gain electric power from controlled thermonuclear fusion. The idea is to use laser light to evaporate, ionize and implosively compress a solid fuel pellet and thus trigger nuclear fusions.... Now the Sandia Laboratories in Albuquerque have announced a new laser that appears to be a significant step on the way.

UPDATE: Laser fusion is starting to hit its stride. Scientists at Lawrence Livermore National Laboratory in California use 192 laser beams to blast a target with millions of joules of energy in an attempt to initiate fusion. Last year, the lab achieved ignition, in which more energy is released than initially hits the target (*SN: 1/14/23, p. 6*). Then in July, the lab repeated the feat, achieving the highest energy yield yet. A blast of about 2 million joules resulted in an output of nearly 4 million joules of fusion energy, according to a lab statement. But much more energy is required to power the laser facility, meaning laser fusion still isn't a net power source.



HOW TO

Run a marathon in under two hours

In an unofficial race in Vienna in 2019, Eliud Kipchoge, a Kenyan long-distance runner, became the first person ever to run a marathon in under two hours, clocking in at 1:59:40. A new study shows how teamwork made that feat possible.

Kipchoge ran with a rotating posse of pacers, other runners who deflected some of his air resistance in a process known as drafting. Now, wind tunnel tests with action-figure manikins suggest that those pacers saved him

TEASER

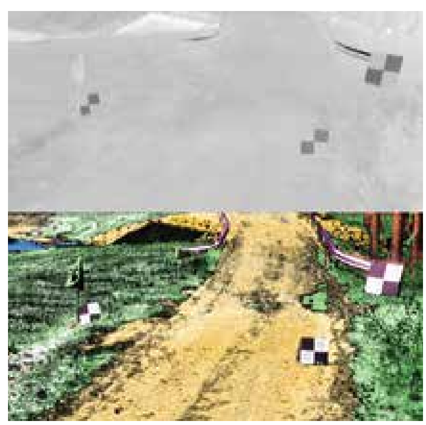
Artificial intelligence sharpens blurry thermal vision

The fuzzy, ghostly figures typically seen in thermal images might become a thing of the past. By pairing artificial intelligence and thermal vision, scientists can make crisp, detailed images — even in the dark. Described in the July 27 *Nature*, the technique could one day help improve self-driving cars' ability to navigate at night.

Thermal imaging works by detecting heat sources. Infrared images are blurry because of a phenomenon called ghosting. Heat from an object overwhelms any details about the object's texture, much like how turning on a lightbulb makes it difficult to decipher the etching on it.

Physicist Fanglin Bao of Purdue University in West Lafayette, Ind., and colleagues used a thermal camera that distinguishes various wavelengths of infrared light. A computer program that uses AI to reveal the temperature, texture and material of objects in an image then created bright, detailed nighttime scenes from the camera's data.

Because the technique measures distance with about the same accuracy as current cameras, it could help self-driving cars know when to brake to avoid a wreck. But it won't be cruising busy streets anytime soon. Creating an image takes about a second — too slow for a self-driving car to respond in real time. *— Luis Melecio-Zambrano*



A ghostly thermal image of a forest road (top) was sharpened by AI based on the temperature, texture and material of objects detected in the image (bottom).

FROM TOP: ALEX HALADA/AFP/GETTY IMAGES; F. BAO *ET AL/NATURE* 2023



In 2019 in Vienna, elite runner Eliud Kipchoge finished an unofficial marathon in under two hours.

3 minutes and 33 seconds, researchers report August 16 in *Proceedings of the Royal Society A*.

An alternative configuration of pacers could have given Kipchoge an even bigger boost, shaving off an additional 49 seconds, the team proposes.

Elite marathon runners are often accompanied by other runners who swap in and out to keep the primary runner on pace. Scientists know from experiments on live participants and from computer simulations that running between these pacers can reduce an athlete's drag.

Mechanical engineer Massimo Marro of the École Centrale de Lyon in France and colleagues measured the drag force felt by manikins in a wind tunnel, which allowed the team to test different drafting configurations readily.

Inside the tunnel, the team replicated Kipchoge's 2019 formation, which featured five pacers in a V in front with two more in the rear. This arrangement reduced the drag felt by the athlete by about half — enough to trim about three and a half minutes off his time, the researchers found.

Marro and colleagues also identified several other formations that could further maximize performance. Rather than a V, the winning design sets the five pacers in front in a formation shaped like a lowercase t: one pacer behind another, followed by two side by side and then one more pacer behind that pair.

The researchers estimated the drag Kipchoge would have felt running by himself to calculate the predicted savings from this new formation: 4 minutes, 22 seconds.

Using the t formation, "you can sort of slice through the air with a narrower wedge," says Rodger Kram, a physiologist at the University of Colorado Boulder who was not involved with the research. "That's quite innovative."

While official races usually allow runners only two or three pacers, Kram suggests that competing athletes could make use of cooperative drafting, which involves taking turns coasting in each other's shadows to boost performance.
— Zack Savitsky

SCIENCE STATS

Ultrafast black holes

Colliding black holes can launch newly melded cosmic sinkholes at speeds up to nearly 10 percent of the speed of light, or about 28,500 kilometers per second, scientists at the Rochester Institute of Technology in New York report in the Aug. 18 *Physical Review Letters*. Black holes stir up ripples in spacetime as they merge. If the cosmic union blows ripples more in one direction, the emerging black hole will recoil in the opposite direction. The team calculated the speeds of recoils by simulating tons of interactions, from flybys to head-on crashes. Grazing collisions spit out the fastest black holes. The work gives insight into to the energy that black hole mergers release. *— Nikk Ogasa*

28,500
kilometers per second
Estimated maximum speed of a recoiling black hole

RETHINK

Ötzi is still full of surprises



A new look at Ötzi the Iceman's DNA reveals that his ancestors weren't who scientists once thought. Ötzi's complete genome, compiled in 2012, suggested that the frozen mummy found on the border between Austria and Italy had ancestors from the Pontic-Caspian steppe, which encompasses much of central and eastern Europe. But something didn't add up. Ötzi, shown at right, died about 5,300 years ago. Other people with steppe ancestry didn't appear in central Europe until about 4,900 years ago. He "is too old to have that type of ancestry," says Johannes Krause of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. It turns out that modern DNA heavily contaminated the 2012 genome, Krause and colleagues report August 16 in *Cell Genomics*. A newly compiled genome reveals no steppe ancestry. Instead, most of Ötzi's genetic heritage comes from Neolithic farmers. He also had darker skin than artistic depictions suggest. Genes conferring light skin tones didn't become prevalent until 4,000 to 3,000 years ago, Krause says. *— Tina Hesman Saey*

SÜDTIROLER ARCHÄOLOGIEMUSEUM, MARCO SAMADELLI/EURAC, GREGOR STASCHITZ



Human ancestors may have flirted with extinction roughly 930,000 to 813,000 years ago before bouncing back and possibly evolving into *Homo heidelbergensis*, a species represented by the fossil skull shown here.

ANTHROPOLOGY

Human ancestors nearly went extinct

The controversial claim rests on a statistical analysis of DNA data

BY BRUCE BOWER

Human ancestors almost died out nearly a million years ago in an evolutionarily pivotal population bust, a contested new genetic study concludes.

This potential winnowing of human ancestors into a barely sustainable number of survivors coincided with a period of extreme cold and droughts in Africa and Eurasia, geologic evidence indicates.

If the scenario holds up, relatively few survivors of the Stone Age chill may have evolved into a species ancestral to *Homo sapiens*, Neandertals and Denisovans, say population geneticist Wangjie Hu of the Icahn School of Medicine at Mount Sinai in New York City and colleagues. Previous analyses of DNA from ancient fossils estimate that this common ancestor appeared around 700,000 to 500,000 years ago.

Not long before that, members of the human genus, *Homo*, weathered a roughly 117,000-year freeze while maintaining an average of 1,280 individuals capable of breeding, the team reports in the Sept. 1 *Science*. That whittled-down population reproduced just enough to stave off extinction, the researchers say.

Before the onset of the harsh climate, the number of potential breeders in the same ancestral population had totaled between 58,600 and 135,000 individuals, Hu and colleagues calculate.

The team devised a statistical method to estimate the timing and sizes of ancient breeding populations using patterns of shared gene variants in human populations today. The modern genetic data came from 3,154 people in 10 African populations and 40 non-African populations.

The scientists calculated the expected diversity of these modern variants based on hypothetical ancient population histories, some of which included periods of drastic declines in numbers of breeding adults. A population crash among human ancestors that lasted from about 930,000 to 813,000 years ago best accounts for the genetic variation, the team concludes.

Africans have much stronger genetic evidence of an ancient population crash than non-Africans do, the scientists found. A depleted population of human ancestors probably lived in Africa starting around the beginning of the alleged crash, though Eurasia can't be ruled out as a home for the survivors.

As that diminished population began to rebound, its members may have evolved into *H. heidelbergensis*, the team suspects. Some scientists regard *H. heidelbergensis* as the common ancestor of Denisovans, Neandertals and *H. sapiens*. But others say that fossils assigned to *H. heidelbergensis* contain too many differences to qualify as a single species.

In a commentary in the same issue of *Science*, archaeologist Nick Ashton of the British Museum in London and paleoanthropologist Chris Stringer of London's Natural History Museum provisionally accept the new findings. Even so, an increasing number of fossil discoveries suggest that groups in the *Homo* genus occupied parts of Africa and Eurasia at the time of the proposed crash. More DNA from ancient hominids will help clarify when and where ancient population crashes occurred, the researchers say.

Severe climate shifts might have pushed human ancestors and other species close to or over the brink of extinction, Hu's team suggests. In the Aug. 11 *Science*, Ashton, Stringer and colleagues describe a previously unknown cold phase in Europe that may have led to sharp declines in hominid numbers about 1 million years ago. Populations unrelated to later *H. sapiens* that lived in Africa and Eurasia may have survived such bouts of cooling better than groups related to people today, Hu's team says.

Stephan Schiffels, a population geneticist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, doubts the study's conclusions. Interconnected ancestries among ancient *Homo* groups and statistical uncertainties in determining their genetic ties obscure any molecular signs of population collapses that occurred nearly 1 million years ago, Schiffels contends. "The suggested precision in dating events like this is not possible," he says. And the present-day human DNA that Hu's team analyzed has been studied for years by other investigators, none of whom have cited any signs of an ancient and steep population decline.

Hu's team plans to add ancient hominid DNA and more modern human DNA, especially from Africa, into further analyses of ancient population ups and downs. ■

PLANETARY SCIENCE

India's lunar mission stuck the landing

The success follows recent failed attempts by Russia and Japan

BY KATHERINE KORNEI

Space is hard, as the saying goes.

As humans have endeavored to launch themselves and their machines beyond Earth, that maxim has been proved again and again. Recent attempts to touch down on the moon — a feat first accomplished nearly 60 years ago by the former Soviet Union's robotic Luna-9 probe — have been particularly fraught with failure.

But on August 23, an Indian spacecraft successfully landed on the moon, a first for a South Asian country.

The Chandrayaan-3 mission, which launched July 14, delivered the Vikram lander and the Pragyan rover to the south pole of the moon, a region previously unvisited by spacecraft and thought to contain water ice (SN: 6/18/22, *p.* 9).

Such reservoirs of water ice would provide a crucial source of drinking water for any future lunar inhabitants as well as hydrogen for fuel. An instrument aboard the Pragyan rover has been collecting data about the composition of the surface near the south pole.

This was the country's second attempt at a lunar landing, following the crash of Chandrayaan-2's lander in 2019. Vikram's landing catapults India into a rarefied group of nations that have successfully made a controlled "soft landing" — rather than an uncontrolled "hard landing" — on the moon: the United States, the former Soviet Union and China (SN: 12/21/19 & 1/4/20, *p.* 31). India's success, however, follows close on the heels of recent failures by other countries.

On April 25, Japan's Hakuto-R Mission 1 lander crashed on the moon's surface. According to ispace, the private company that developed the mission, the crash occurred because onboard software miscalculated the lander's altitude above the lunar surface. The lander was slated to touch down in Atlas crater on the nearside of the moon and study lunar dust.

Then on August 19, Russia's Luna-25 lander also crashed into the moon. The car-sized spacecraft had been orbiting the moon for several days when, according to Russia's space agency, communications were lost after the craft fired its engines during prelanding maneuvers. Luna-25 was bound for the vicinity of Boguslavsky crater near the moon's south pole, where it would have studied the moon's surface and tenuous atmosphere.

Despite the moon being just under 400,000 kilometers from Earth, it is a challenging target for spacecraft seeking to land. That's in large part because our nearest celestial neighbor largely lacks an atmosphere.

The go-to mechanism for slowing down a descending object approaching Earth — a parachute — is therefore useless, says Dave Williams, a lunar and planetary scientist at NASA's Goddard Space Flight Center in Greenbelt, Md.

"The only way to slow yourself down is with rockets," Williams says. That's where things get tricky, since firing a rocket means controlling its orientation and thrust, among other things, he says.

If something were to go awry, the moon's gravity — while only one-sixth that of Earth's — is strong enough to slam a spacecraft into the surface with enough force to destroy it, Williams says. (Spacecraft landing on a comet or asteroid have it easier because those bodies' gravitational fields are generally so weak there's little danger of a crash.)

There's also the challenge of determining a safe landing site on the moon. An area that appears smooth as seen from orbit might in fact be littered with boulders or other obstacles, Williams says. A spacecraft's software must be capable of evaluating the terrain on its own.

Relying on human operators on Earth isn't feasible, Williams says, because there's too long of a lag in communications due to the finite speed of light. "You're always 2.5 seconds behind."

Even so, the moon remains an appealing target. Japan's Smart Lander for Investigating Moon, or SLIM, mission is slated to launch later this year. If all goes well, the probe will eventually touch down near Shioli crater on the moon's nearside. ■



RAJESH KUMAR SINGH/AP PHOTO

At the Kashi Integrated Command and Control Centre in India, people look on as the country's Chandrayaan-3 mission approaches the surface of the moon on August 23.

HEALTH & MEDICINE

Semaglutide may benefit the heart

Study raises questions about other uses for a diabetes drug

BY MEGHAN ROSEN

A medication for diabetes and weight loss could be on the verge of scoring a hat trick: It may also be a cardiovascular wonder drug.

But results from a new clinical trial have raised a flurry of questions. Who benefited from the drug and how long did they need to be treated? What were the side effects? And are the newly reported cardiovascular effects driven by weight loss, or is the medication working in some other way?

Approved as a diabetes drug, the molecule semaglutide mimics the gut hormone GLP-1. This hormone typically suffuses into our bloodstreams after we eat and makes us feel full, among other actions. Semaglutide gives people an extra dose of that full-feeling hormone.

Taking the drug can lead to dramatic weight loss — and now, it appears, better cardiovascular health, even in people without diabetes. At least, that's the take-home message of early clinical trial results released August 8 by the drug's maker, Novo Nordisk, which is headquartered in Copenhagen. Weekly injections of semaglutide in overweight or obese adults cut the risk of serious heart or blood vessel problems by 20 percent, the company reported.

"It's quite a big deal," says David Strain, a physician at the University of Exeter Medical School in England who recruited patients for the trial but did not collect data. "This is the first time that a drug for weight loss has shown benefits above and beyond the weight loss itself."

Headlines have hailed the trial as a landmark. The study's early results served up the tantalizing idea that semaglutide might prevent strokes or heart attacks in a broad group of people. In the United States alone, over 795,000 people have strokes every year and about 805,000 people have heart attacks.

But Novo Nordisk's brief report is sparse on details and has left doctors and scientists awaiting the trial's full findings. Scientists involved with the trial plan to present more information later this year.

Before making any judgments or recommendations, the study needs to be peer-reviewed, says cardiologist Michelle Albert of the University of California, San Francisco. "If the results seem sound, [the study] opens the door for a wider range of folks benefiting from this medication. But this is all a big if."

Semaglutide's path to the public has been a long one. Since the mid-2000s, scientists have launched more than 300 clinical trials testing the drug. In 2017, the U.S. Food and Drug Administration approved semaglutide for use in people with type 2 diabetes, sold under the brand name Ozempic. It is now for sale in self-administered injector pens containing up to two milligrams of semaglutide.

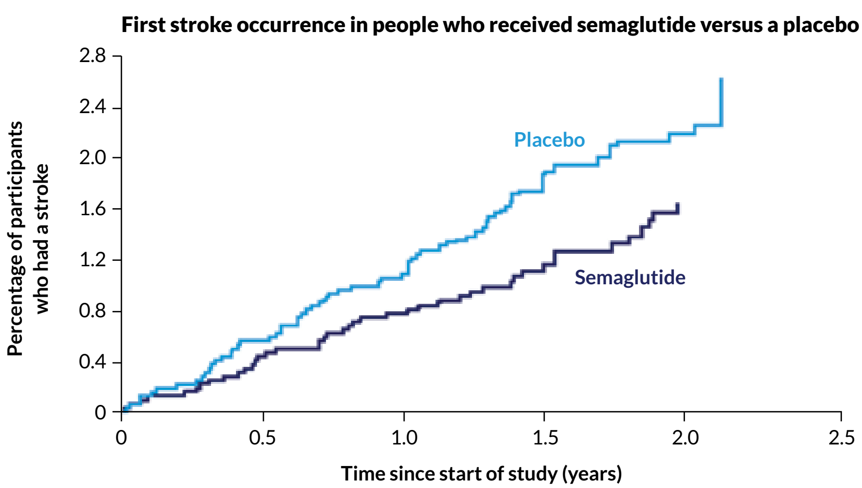
About four years after Ozempic got the green light, the FDA approved a 2.4-milligram version, brand name Wegovy, specifically for weight management. People treated with the drug tend to be less hungry, have fewer cravings and feel more satiated after eating than those not on the drug — all factors that may translate to weight loss. In one 2021 study, people treated with the drug for more than a year lost about 15 kilograms (about 11 pounds). People who instead received a placebo lost less than three kilograms.

Other studies have unearthed cardiovascular clues suggesting semaglutide may do more than simply help people shed pounds. In a small trial of people with obesity and one type of heart failure, taking the drug for a year seemed to improve physical abilities, researchers reported August 25 in the *New England Journal of Medicine*. And last year in *Stroke*, Strain and colleagues reported that semaglutide lowered the risk of stroke in people with type 2 diabetes and high cardiovascular risk. How exactly it works remains unclear, Strain says, but it's possible the drug reduces damage from blood flow blockages in the brain.

That kind of secondary effect may help explain the results of Novo Nordisk's current clinical trial, called SELECT, which enrolled more than 17,000 adults age 45 and older. The trial evaluated semaglutide's effects in people who were overweight or obese. These people did not have diabetes, but they did have cardiovascular disease. Weekly injections reduced the number of fatal or nonfatal strokes and heart attacks, the company reported, though it did not provide actual numbers. A smaller trial funded by Novo Nordisk in 2016 reported similar results in people with diabetes treated with the drug.

But there are big questions raised by the SELECT trial that still need to be answered, Strain says. For example, how long do the

Stroke reduction In a 2022 study of the diabetes drug semaglutide, people with type 2 diabetes and high cardiovascular risk who took the drug (dark blue) were less likely to have a stroke than those who received a placebo (light blue). All participants had no prior history of stroke.



W.D. STRAIN *ET AL*/*STROKE* 2022

cardiovascular benefits persist after people go off the drug? Weight loss, at least, doesn't seem to endure. In one 2022 study, people regained two-thirds of the weight they had lost a year after stopping the medication. And how much of Wegovy's cardiovascular benefits are due to slimming down versus other ways semaglutide may be tinkering with the body?

Strain suspects that weight is not the only factor. In the stroke study, his team noticed that stroke risk fell relatively quickly — before participants lost a lot of weight. "That was the biggest surprise to us," he says. "You start seeing the benefit within a few months after starting the drug." Strain expects to see something similar with the SELECT trial. But teasing out the ways semaglutide affects cardiovascular health "is going to take a lot of unpacking," he says.

Albert has questions about the SELECT participants. How many of them stuck with the drug regimen and for how long? And do the side effects offset the drug's utility? Semaglutide can roil the stomach, causing nausea, diarrhea and vomiting.

She also wonders which participants experienced cardiovascular benefits. "What's their racial and ethnic background? What's their gender? What's their income level?" Albert asks. Weight issues often start in childhood and can relate to finances, access to healthy foods and socioeconomic status, she notes. She's curious if semaglutide's effects are uniform across different subgroups of people.

Gastroenterologist Andres Acosta of the Mayo Clinic in Rochester, Minn., is intrigued by the tidbits that Novo Nordisk has released and is waiting to see the full results. Still, he thinks the study might help the public view obesity in a new light. In the United States, roughly 120 million people are obese. Worldwide, that number surges to more than a billion.

"Many people still think that obesity is a disease that is purely cosmetic," Acosta says. Studies like the SELECT trial suggest that treating obesity isn't just about looks, it's about saving lives. "We need to stop ignoring the problem," he says. "Obesity should be treated — and treated seriously." ■

HEALTH & MEDICINE

Health risks can linger after COVID-19

Even mild infections lead to debilitating symptoms that last years

BY BETSY LADYZHETS

The risk of experiencing health issues such as diabetes, fatigue or blood clots can persist for at least two years after an infection with the coronavirus.

That finding, described August 21 in *Nature Medicine*, is based on the health records of about 140,000 U.S. veterans who had COVID-19 early in the pandemic, compared with those of nearly 6 million veterans who didn't test positive. Scientists used new diagnoses of health issues, lab results and prescription records to track 77 health problems that emerged starting a month after getting COVID-19.

Even two years after infection, people who had COVID-19 were at higher risk for health issues ranging from heart disease to gastrointestinal problems, the team found. Patients with milder infections — about 120,000 people — were at higher risk for 24 of the 77 medical issues, while patients who were initially hospitalized for severe COVID-19 were at higher risk for 50 of the 77 issues. That suggests worse symptoms in the acute phase of a COVID-19 infection can contribute to a greater chance of developing long COVID. Initially hospitalized patients also had higher risks of hospitalization or dying in the two years following their COVID-19 infections, the team found. For patients with milder infections, those risks tapered off.

But since most COVID-19 cases are milder, this group represents a greater burden to the health care system, says clinical epidemiologist Ziyad Al-Aly of the Veterans Affairs St. Louis Health Care System and Washington University. A coronavirus infection can "result in heart disease, result in brain problems," and many other long-term risks that scientists are just beginning to understand.

The most common problems — fatigue, memory problems, loss of smell, blood clots, metabolic issues and gastrointestinal problems — align with common long COVID symptoms identified in other studies (SN: 11/5/22, *p. 22*). For example, initially hospitalized patients were nearly two times as likely to experience acute gastritis, or stomach inflammation, as those with no record of COVID-19 at two years after infection. Nonhospitalized patients had a risk factor of 1.44 times.

The findings match patients' experiences with persistent symptoms, says Lisa McCorkell of the Patient-Led Research Collaborative, a group of scientists who have long COVID and use their expertise to research the disease. For instance, autonomic nervous system issues, which can lead to symptoms like pain and fatigue, persisted for both groups of patients in the study and even increased over time for the nonhospitalized group.

For every 1,000 people infected with the coronavirus, a cumulative 150 years of healthy life is lost due to these patients' struggles with persistent symptoms, Al-Aly and colleagues found.

That demonstrates "how destructive long COVID can be," McCorkell says. Other studies, such as the U.S. Census Bureau's Household Pulse Survey, similarly found that long COVID can severely restrict day-to-day life for many patients.

Because the study analyzed electronic health records, the team couldn't assess some common long COVID symptoms that aren't typically captured by doctor's visits, such as post-exertional malaise. And about 90 percent of the records studied were from men, while long COVID and other similar chronic conditions are more common in women. That means some prevalent symptoms may be underrepresented.

The study also didn't include people who may have had COVID-19 but failed to test positive in early 2020, when tests were not widely available. Many of the people included as controls might have had COVID-19, says physician Upinder Singh of Stanford University's long COVID clinic.

Still, with COVID-19 cases rising again, the study offers a reminder that "it's still worth it to protect yourself," Al-Aly says. ■

CLIMATE

How hot is too hot for tropical forests?

More leaves hitting their heat limit might threaten tree survival

BY NIKK OGASA

Like people, leaves have their limits when it comes to heat.

Scientists first reported in 1864 that the leaves of some plants could survive temperatures of up to 50° Celsius, only to perish beyond that threshold. More than 150 years later, researchers are making similar findings. In 2021, a study of 147 tropical plant species found that the average temperature beyond which photosynthesis failed was 46.7°.

Now, in the upper canopies of Earth's tropical forests, roughly 1 in every 10,000 leaves experiences temperatures at least once annually that may be too high for photosynthesis, researchers report in the Sept. 7 *Nature*.

That might seem a paltry sum, but a photosynthetic breakdown could harm entire forests if climate change is not halted, the scientists warn. A rise of about 4 degrees above current average temperatures in tropical forests could potentially cause wide swaths of leaves to die en masse, simulations suggest. Still, the researchers acknowledge that the prediction comes with uncertainties.

"One small possibility … is an incredibly dire tipping point" beyond which tropical forests perish, Christopher Doughty, an ecologist at Northern Arizona University in Flagstaff, said August 21 at a news briefing. But "there's a lot we don't know."



Some leaves in the upper canopies of tropical forests endure temperatures that exceed the limit for photosynthesis.

When leaves get too hot, their photosynthetic machinery — proteins that convert light energy into sugars — breaks down. To figure out whether tropical forests were approaching such a threshold, Doughty and colleagues obtained data collected by ECOSTRESS, a thermal sensor aboard the International Space Station that captures vegetation temperatures on Earth's surface in 70-square-meter pixels. That's about the area that two large tropical trees could fill.

4

degrees Celsius

Amount of warming that may cause die-offs of leaves in tropical forests

The team compared the data with measurements from devices on Earth's surface. These included an instrument in the Amazon, mounted high on a tower, as well as swarms of sensors taped to the bottoms of leaves in Brazil, Puerto Rico, Panama and Australia.

The analysis revealed a mosaic of temperatures in forest canopies. When forests were hot and their soils dry, temperatures across the canopy could reach an average peak of 34°. But there was variability; some tracts exceeded 40°.

The comparison also revealed a detail unseen by ECOSTRESS — a scatter within the mosaic. Individual leaf temperatures varied in single forest tracts, with some leaves reaching temperatures that far exceeded the tract average. Upper canopy leaves sweltered at temperatures above the 46.7° threshold about 0.01 percent of the time, the team found.

The scientists also analyzed data from leaf-warming experiments in Brazil, Puerto Rico and Australia. Each degree of ambient warming had a disproportionate impact on leaf temperatures, the experiments showed. For example, when Amazon leaves were subjected to an additional 2 degrees of ambient warming, maximum leaf temperatures rose from about 43° to about 51°.

Using the experimental data along with the satellite and ground-based data, the team simulated the future of tropical forests under climate change. Most forests could endure about 4 degrees of warming above current average levels before trees lose all their leaves, and potentially die, the simulations suggest. That amount of warming might be possible by 2100 in a worst-case scenario in which greenhouse gas emissions continue rising through the century, the researchers say.

Still, there's a lot of uncertainty. That's in part because the adaptive capabilities of different tree species and how the deaths of individual leaves impact a tree's mortality aren't well understood.

The study may overestimate vulnerability by "assuming that when leaves hit this critical temperature, they die," says ecologist Christopher Still of Oregon State University in Corvallis. While that is possible, just how long it takes various temperatures to kill the leaves of different species is unclear, Still says.

Predicting the future of these forests will also require more insights into what's unfolding beneath the canopy, says ecologist Marielle Smith of Bangor University in Wales. "There is still a question mark over the role of small trees and understory leaves, which aren't going to be as hot."

Among tropical forests, the Amazon may be most vulnerable to the type of reckoning predicted by the researchers. "There's more trees dying [there] now than there were 10 years ago or 20 years ago. We don't see that in Africa," Doughty said. That could be because "temperatures are a bit hotter … in the Amazon than in Africa."

Some researchers have been warning for years that climate change and deforestation could trigger large parts of the Amazon to transform into savanna and shrubland (SN: 6/17/23, *p.* 18).

"This is a glimpse into a potential tipping point. It's not saying that the tropical forests are now going to be savannas tomorrow," study coauthor and ecologist Joshua Fisher of Chapman University in Orange, Calif., said at the briefing. "We can now see this insight … and because we can see that, it means we can act." ■

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ANIMALS

Melting ice killed emperor penguins

Several colonies lost all their chicks in 2022, scientists say



Thousands of emperor penguin chicks have died due to dwindling Antarctic sea ice in recent years.

BY LUIS MELECIO-ZAMBRANO

Thousands of emperor penguins in western Antarctica lost their chicks in 2022, largely due to receding sea ice, satellite data suggest.

Antarctic sea ice has reached record lows in recent years. While looking at satellite images in 2022, geographer Peter Fretwell noticed ice in the Bellingshausen Sea was melting especially early in the year. He wondered how emperor penguins (*Aptenodytes forsteri*) there were faring.

So Fretwell and colleagues analyzed satellite images of colonies to determine the fate of the breeding season. Of the five colonies observed, four probably lost all their chicks, the team reports August 24 in *Communications Earth & Environment*.

Emperor penguins rely on stable sea ice throughout their breeding season, which usually lasts from April to January. In the months after hatching, a chick loses its downy feathers and gains a waterproof coat before fledging. Last year, sea ice broke up before some colonies were done fledging. Chicks without waterproof feathers were unable to survive, says Fretwell, of the British Antarctic Survey in Cambridge, England. Of the youngsters from the 10,000 or so breeding pairs in the region, "about 850 of the chicks survived," he says.

Penguin colonies can recover from a single failed breeding season, says seabird ecologist Annie Schmidt of Point Blue Conservation Science in Petaluma, Calif. And the team looked at only a few colonies of the dozens throughout Antarctica.

But some of those other colonies have also experienced bad breeding seasons lately. On Antarctica's Brunt Ice Shelf, the world's second-largest emperor penguin colony at the time had three years of breeding failure from 2016 to 2018 after storms broke up sea ice there, Fretwell and a colleague previously reported. Between breeding failure and mass migration to another site, the colony all but disappeared.

Repeated or more widespread failure could threaten colonies and emperor penguins as a species. The newly documented breeding failure across several colonies at once "is the first observation that's in line with the worst expectations of what could happen" as the Earth continues to warm, Schmidt says. "It's not a good sign." ■

ANIMALS

Scientists revive frozen adult corals

Cryopreservation could help rebuild reefs in a warmer world

BY NIKK OGASA

Like something out of science fiction, small colonies of mature corals have been safely frozen and revived for the first time, though more work will be needed to ensure their long-term survival, scientists report August 23 in *Nature Communications*. Freezing chunks of living corals for safekeeping could save them from extinction as the oceans heat up and acidify from human-caused climate change (*SN: 10/29/16, p. 18*).

Scientists had already cryopreserved and revived coral larvae with success. But larvae are accessible only when corals spawn, so just a few nights each year, says marine scientist Liza Roger of Arizona State University in Tempe. "That's putting a lot of eggs in one basket." What's worse, she says, coral reproduction is struggling, and fewer larvae are surviving due to warming seas.

One solution is to cryopreserve mature coral colonies, which are available year-round. Preserved adult corals could help rebuild reef ecosystems in more hospitable seas. But for large specimens, it's difficult to prevent ice from forming and damaging tissues.

Thermodynamicist Matthew Powell-Palm of Texas A&M University in College Station and colleagues experimented with freezing pea-sized pieces of a common Hawaiian finger coral, *Porites compressa*. After removing microbes that could interfere with preservation, the team sealed coral fragments in metal chambers filled with a dehydrating chemical solution and plunged the chambers into liquid nitrogen.

Amid the roughly –200° Celsius temperatures, the remaining water in the corals solidified into a glassy form without expanding into ice crystals. In such frigid conditions, Powell-Palm says, metabolic reactions and other life-driving processes "crawl to such an infinitesimally slow pace, you could preserve [living specimens] for hundreds, possibly thousands of years."

After a couple minutes spent in cryopreservation, the corals were pulled from the nippy nitrogen, carefully thawed and monitored for 24 hours. One day after thawing, the corals were alive and well.

The results are promising, but the team's work isn't finished, Roger says. As things stand, a few days after thawing, the corals were still so stressed out from the cryopreservation process, they were overrun and killed by bacteria they normally live in harmony with. The next steps should be to help the revived reef builders survive in the long-term, she says. ■

CHRISTOPHER WALTON

ASTRONOMY

Active black holes elude astronomers

Few behemoths display signs of growing up fast, a survey finds

BY DARREN INCORVAIA

Fewer supermassive black holes may undergo growth spurts than astronomers had suspected.

Every known large galaxy hosts a gargantuan black hole at its center. Some of those behemoths experience bursts of beefing up, during which time they blaze brightly. But recent observations from the James Webb Space Telescope, or JWST, turned up far fewer of these active black holes than expected, researchers report in a paper posted August 22 at arXiv.org.

If confirmed, the finding raises questions about how some supermassive black holes grew so big and what, if any, impact they have on the galaxies they inhabit.

Huge black holes such as the one at the center of the Milky Way tend to be pretty quiet (*SN: 8/12/23, p. 4*). Occasionally, a surge of interstellar detritus rains down on them — often following a collision with another galaxy — creating a period of fast growth called an active galactic nucleus, or AGN. Here, the heart of the host galaxy emits a lot of light at all wavelengths as the influx of material swirling around the black hole heats up. AGNs, which can outshine their host galaxies, are the brightest persistent sources of light in the universe.

Astronomer Allison Kirkpatrick of the University of Kansas in Lawrence and colleagues predicted that JWST's infrared eyes would find a lot of these active black holes based on data from other space-based infrared telescopes. So the team turned JWST toward a well-studied strip of sky where the Spitzer Space Telescope had found infrared AGN signatures in nearly a third of 19 galaxies it looked at.

Seen as they were at the peak of cosmic star formation roughly 10 billion years ago, the Spitzer galaxies were all relatively bright and massive. Because JWST is more sensitive than Spitzer, it's capable of spotting fainter galaxies in the same epoch that are more comparable in size to the Milky Way. Yet, out of the nearly 500 galaxies that JWST spotted, all observed for the first time, just 6 percent appear to contain AGNs, the team reports.

"We are actually probing a new population" of galaxies, says Tonima Tasnim Ananna, an astronomer at Wayne State University in Detroit who was not involved in the work. The data come from the far reaches of the universe, a region that JWST has made more accessible than ever.

The newfound galaxies appear to be filled with dust. It's possible that fast-growing black holes are hiding in these distant dusty galaxies and researchers just don't have the technical capabilities to identify them yet, Kirkpatrick says.

But if there really aren't as many of these fast-growing black holes as once thought, it would throw astronomers' understanding of black hole and galaxy formation for a loop. Supermassive black holes can weigh as much as several billion suns. The AGN phase is thought to be an important step for gathering so much mass.

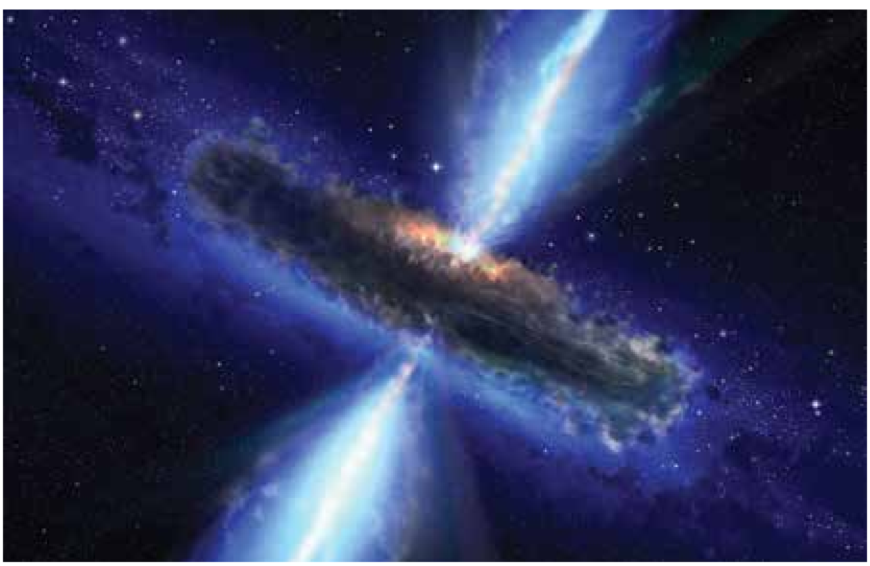
"Maybe all galaxies don't go through this active phase, [and] their black holes grow pretty slowly," Kirkpatrick says. This would mean that some supermassive black holes would need to have started out relatively hefty, rather than growing up from comparably tiny objects.

An active black hole doesn't just grow quickly in isolation. It also affects its host galaxy. "It gets really, really hot" in an AGN, Kirkpatrick says. That can make it harder for the host galaxy to form stars, which need relatively cool gas to get started.

And the pressure around a rapidly accreting supermassive black hole can be powerful enough to launch winds "like a trillion hurricanes just ripping through your galaxy," Kirkpatrick says. These winds could in turn make things too unstable near the galaxy's center for planets to form that are capable of sustaining life, she says. But if many black holes aren't going through an AGN phase, most galaxies may not be influenced by supermassive black holes all that much.

Another explanation for the dearth of active supermassive black holes in JWST data: Many of them might grow via bursts of activity that happen more quickly than a typical AGN. "The faster a process happens, the lower the chance we can detect it," Kirkpatrick says. "We'd have to be looking at the right patch of the sky with the right tool at the right time." If the black holes flicker for brief spurts, she says, "you're never going to find these things. You're never going to be able to understand how the black holes are growing."

More answers could be coming soon. Kirkpatrick plans to search with JWST again in January. "I'm going to have probably 4,000 galaxies to look at," she says. ■



Some supermassive black holes go through a phase of rapid growth, forming an active galactic nucleus (illustrated) that can glow brighter than the surrounding galaxy.

ESA, NASA AND PAOLO PADOVANI/AVO PROJECT



A partially unearthed platform at a pre-Inca site in Peru may have amplified the sounds of stomping dancers as they ritually honored their thunder god, an archaeologist contends.

PIACI/ORP PROJECT

ARCHAEOLOGY

Ancient platform drummed up thunder

Pre-Inca dancers may have stomped salutes to their thunder god

BY BRUCE BOWER

Roughly a century before the Inca Empire came to power in 1400, blasts of human-produced thunder may have rumbled off a ridge high in the Andes.

New evidence indicates that people who lived there around 700 years ago stomped rhythmically on a special dance floor that amplified their pounding into a thunderous boom as they worshipped a thunder god.

Excavations at a high-altitude site in Peru called Viejo Sangayaico have revealed how members of a regional farming and herding group, the Chocorvos, constructed this reverberating platform, says Kevin Lane, an archaeologist at the University of Buenos Aires. Different layers of soil, ash and guano created a floor that absorbed shocks while emitting resonant sounds when people stomped on it.

This ceremonial surface worked like a large drum that groups of 20 to 25 people could have played with their feet, Lane reports in the September *Journal of Anthropological Archaeology*. The finding, from a ridgetop ritual area that faces a mountain peak, provides a rare glimpse of the roles that sound and dance played in ancient societies (SN: 12/18/10, *p.* 8).

While working at Viejo Sangayaico in 2014, Lane's team noticed that one of two open-air platforms located in a ritual area sounded hollow when people walked on it. A later excavation of part of the platform uncovered six sediment deposits consisting of various mixes of silty clay, sand, ash and other materials. Ashy layers within a section of guano from animals such as llamas and alpacas included small cavities that helped to generate drumlike sounds from the platform's surface, Lane says.

His team tested the platform by stomping on it one at a time and in groups of two to four while measuring the noise produced. In one instance, a circle of four people stomp-danced across the platform.

The sounds ranged in intensity from 60 to 80 decibels, roughly equivalent to between a loud conversation and a noisy restaurant, Lane says. Larger groups of Chocorvos dancers, possibly accompanied by singing and musical instruments, would have raised a much bigger racket.

Spanish historical documents describe Chocorvos' beliefs in thunder, lightning, earthquake and water deities. Supernatural convictions may have inspired ancient ceremonies at Viejo Sangayaico that included stomp dancing aimed at emulating a thunder god's signature blasts, Lane suggests. In line with that suggestion, remains of a possible temple near the percussive platform included pottery pieces displaying snake images that, in the local Quechua language, refer to water or rivers and, in some instances, lightning.

Pre-Inca stomp dancing may also have influenced a dance practiced by the Chocorvos and other Andean groups in the mid-1500s, after Spanish conquest of the Incas in 1532, Lane suspects. The Chocorvos had been subjects of the Inca Empire for most of its run. As part of a resistance movement against Spanish culture called Taki Onqoy, Andeans danced and trembled in circles, possibly to evoke spirits of their traditional deities.

Finding another percussive platform along with artifacts related to water and lightning rituals at other ancient Andean sites would better support Lane's argument, says anthropological archaeologist Kylie Quave. To that end, researchers can now excavate platforms at other sites to check for guano layers and other elements of drumlike dance floors, says Quave, of George Washington University in Washington, D.C.

Whether makers of the Viejo Sangayaico platform designed it to amplify sounds, Chocorvos people could have discovered the surface's drumlike properties and then used it for ceremonial dancing, says archaeoacoustics researcher Miriam Kolar of Stanford University. Evidence of other sound-altering structures have been found at older Andean sites, Kolar says. Conch-shell horns found in a ceremonial center at a roughly 3,000-year-old site called Chavín de Huántar could produce nearly pure tones to loud roars, sounds that were emphasized in ceremonially important passages and ventilation shafts, Kolar and colleagues have found.

People who live near Viejo Sangayaico today say that another ancient site in the area contains a similar resonating platform. Lane has yet to visit that site.

Finding more sound-amplifying platforms will depend on "having your ear attuned to how different parts of a site sound," Lane says, "which is something that archaeologists rarely do." ■

SCIENCE & SOCIETY

Culture aids Indigenous mental health

Embracing traditional practices helps heal trauma, studies show

BY SUJATA GUPTA

Earlier this year, the leading psychological association in the United States apologized to the country's Indigenous communities for supporting abusive assimilation efforts that have gone on for centuries. Those efforts have included pushing Indigenous people off their lands and separating children from their families for placement in boarding schools.

The harms of such practices are ongoing, the American Psychological Association acknowledged in a February report. Culturally inappropriate mental health diagnoses and treatments have exacerbated disproportionately high rates of mental illness, chronic disease, incarceration and suicide within Indigenous communities. American Indian and Alaska Natives report serious psychological distress 2.5 times as often as members of the general population. They are almost five times as likely to die of alcohol poisoning. And they have the highest rate of suicide of any minority group in the country.

The APA pledged to learn about and value culturally appropriate approaches to care moving forward. And association leaders apologized in person in June at a Society of Indian Psychologists meeting in Logan, Utah, and in August at the APA Convention in Washington, D.C.

The apologies honor the long-standing, often underappreciated, efforts of Indigenous and other researchers working with Indigenous communities. Within the last 15 years, Canada and Australia have issued similar apologies to the Indigenous populations in their countries. Such acts pave the way for the sort of deep changes in thinking and treatment that are needed to help Indigenous communities heal, researchers involved in this work say.

These researchers anchor healing in Indigenous world views that prioritize harmony between people and the planet. And they recognize the powerful role history plays in shaping health and well-being. Indigenous psychology is about "looking at the whole person — the mental, the physical, the spiritual, the emotional — within the context of colonization," says Suzanne Stewart, a psychologist at the University of Toronto and a member of the Yellowknives Dene First Nation in Canada.

Many Indigenous-centered treatments incorporate traditional practices, such as making crafts with local materials, collecting medicinal herbs and engaging in rituals. If the trauma of colonization is the problem, the thinking goes, then cultural revitalization could be the solution.



Indigenous youth skin a moose as part of a hunting camp in Alberta, Canada. In an attempt to heal lingering trauma caused by colonization, some psychologists have been helping Indigenous communities reconnect with culture through such activities.

STEPHANIE TIPPLE

This culture-as-treatment approach is a departure from Western approaches to care, which often minimize historical and cultural contexts. Assessing the success of those methods using measurements typical in Western medicine is difficult. So researchers working in Indigenous psychology are measuring the effectiveness of those programs through qualitative, culturally appropriate methods, such as detailed first-person accounts.

Apologies like the one from the APA mark an important step forward, says psychologist Karlee Fellner of the University of Calgary in Canada and a citizen of the Métis Nation of Alberta. But Feller wonders, can the scientific establishment accept such a radical departure from care and research as usual?

Using culture as treatment

Indigenous understandings of well-being have evolved over tens of thousands of years. These populations are not a monolith; they speak many languages and engage in myriad cultural practices.

But a common thread running through their belief systems is the idea that well-being stems from a healthy relationship between people and their environs, including ancestors, animals and the land, says Patricia Dudgeon, a psychologist at the University of Western Australia in Perth and a Bardi woman from the Kimberley.

In the United States, the idea of restoring this thread gained momentum during the Red Power Movement of the late 1960s to '70s. Activists sought greater autonomy for Tribal nations to protect against further assimilation with white culture. They viewed such assimilation as a form of cultural erasure.

Culture as treatment became so popular that people working in Indigenous communities assumed it worked, says Harvard University psychologist Joseph P. Gone, a member of the Aaniiih-Gros Ventre tribal nation located in Montana. But the theory had gotten ahead of the science. Gone and others began to systematically explore the idea. Those efforts have included developing programs that adhere to Indigenous world views and identifying culturally appropriate ways to measure success.

For instance, Gone partnered with the Blackfeet Nation in Montana to develop a cultural immersion program for people struggling with addiction. During a 12-day pilot program, described in 2015 in *Psychological Services*, four people participated in sweat lodge and pipe ceremonies, pitched tipis, procured food, harvested sacred plants and tanned hides.

The approach can restore Indigenous people's connection to the places and practices — a source of purpose and meaning — that colonization eroded. It has the potential to provide a sense of spirituality that is incompatible with substance use. And it can help people develop new social networks, Gone wrote. "They were engaged in crafting functional contemporary identities and modes of living that were continuous with — rather than alienated from — that past."

> The Western model doesn't account for the historical and ongoing traumas associated with colonization.

Other researchers have modified Western talk therapy for Indigenous clients. Indigenous focusing oriented therapy starts with the idea that trauma in Indigenous communities is intergenerational and shaped by colonization. During a typical session, a therapist and client face the land in front of them rather than each other to acknowledge the vital link between place and well-being. And rather than talk about trauma, clients are encouraged to foster their "felt sense" — using the body's emotions, energies and sensations to express knowledge of how one is part of a larger web of human and nonhuman relationships.

At the Society of Indian Psychologists meeting, Fellner described how her team took the model onto the land. Over 24 days in Alberta, six participants attended therapy sessions and land-based activities, such as making spirit dolls and herbal medicines. During a healing circle, several elders joined the group and shared traumatic stories, such as experiencing the deaths of adult children.

"When we were done sharing, this wicked hailstorm came in and flooded the tipi. We ran into the nearest building when we had the opportunity. We were all drying off. The elders were all laughing," Fellner says. "The land came and helped us."

Questioning the gold standard

Rigorous trials of cultural treatment programs are rare due to low funding, low participation and questions around the appropriateness of measuring Indigenous psychology with Western methods.

Funding difficulties prevented Gone from testing the effectiveness of the Blackfeet cultural immersion program. Part of the problem, he says, is that scientific agencies prioritize incremental changes to existing programs over new approaches.

Researchers who do manage to run randomized controlled trials, the purported gold standard of scientific measurement, often find that cultural treatments don't work as planned, Gone reported in May in the *Annual Review of Clinical Psychology*. But the results are "not big enough to really have confidence in the findings," Gone says. "They're suggesting that culture doesn't matter or that in fact it's harmful but without the proper controls to really have confidence in the findings. That's bad."

The problems with clinical trials are both logistic and cultural. Western psychology rests on certain norms, such as prioritizing self-reliance and autonomy, and the belief that behavior can be broken down into discrete units, the APA report notes. Clinical trials allow researchers to compare outcomes of groups that receive a treatment with those of groups that don't. But it runs counter to the holistic Indigenous understandings of health.

The Western model doesn't account for the historical and ongoing traumas associated with colonization, Stewart says.

And centering sickness in the individual, rather than society, can amplify those wrongs. "To diagnose somebody from an Indigenous perspective in that way, we can cause harm," Fellner says.

The value of firsthand experience

It can be difficult to quantify the results of Indigenous healing practices by Western methods. Instead, Indigenous methods bear closer resemblance to qualitative research than quantitative research. They also prioritize community involvement in developing treatments and center participant voices in the data collection process.

That idea shows up in the National Empowerment Project in Australia. Since 2012, members of Aboriginal communities have been trained to interview fellow community members about issues related to well-being. These community researchers analyze the findings to illuminate key needs, such as a desire for youth and family programming. The process helps turn the researchers into community leaders and empowers communities to take charge of their own healing, Dudgeon and colleagues reported in 2017.

Other methods rely on oral storytelling traditions, such as yarning, a practice in which a researcher listens for particular topics in a participant's story. An analysis of 46 studies that used yarning, described in December in the *International Journal for Equity in Health*, suggests more rigor is needed. Many researchers failed to disclose their ethnic background or connection to a given land — integral context that shapes the power dynamics between interviewer and interviewee.

When it comes to evaluating such programs, participant enthusiasm provides some proof of success. The Blackfeet cultural immersion program continued after research funding dried up, indicating that clients found healing in the culture-as-treatment approach, Gone says. Fellner reports a similar experience. "We don't need a randomized controlled trial to know that Indigenous focusing oriented therapy works," she says. It is working so well that researchers "have not had time to publish."

But with most psychology training grounded in Western thinking, can establishment psychologists accept methods that deviate so far from the status quo? "With all these apologies," Fellner says, "my hope is that they will show us that they really mean it by acknowledging and honoring Indigenous systems of evidence." ■



Jon Nelson, shown here with his son, struggled with severe depression for years.

AIDAN KAHN

Lifting depression with brain implants

How an experimental technology is treating people with severe depression

By Laura Sanders

On a hot, sunny Sunday afternoon in Manhattan, time froze for Jon Nelson. He stood on the sidewalk and said good-bye to his three kids, whose grandfather had come from Long Island to pick them up.

Like any parent, Jon is deeply attuned to his children's quirks. His oldest? Sometimes quiet but bitingly funny. His middle kid? Rates dad a 10 out of 10 on the embarrassment scale and doesn't need a hug. His 10-year-old son, the baby of the family, is the emotional one. "My youngest son would climb back up into my wife's womb if he could," Jon says. "He's that kid."

An unexpected parade had snarled traffic, so Jon parked illegally along a yellow curb on 36th Street, near where his father-in-law was waiting. It was time to go. His youngest gave the last hug. "He looked up, scared and sad," Jon says, and asked, "Dad, am I going to see you again?"

That question stopped the clock. "I was like, 'Oh man,'" Jon says. "It was one of those moments where I was living it through his eyes. And I got scared for the first time."

Until that good-bye, Jon hadn't wanted to live. For years, he had a constant yearning to die — he talks about it like it was an addiction — as he fought deep, debilitating depression. But his son's question pierced through that heaviness and reached something inside him. "That was the first time I really thought about it. I was like, 'I kind of hope I don't die.' I hadn't had that feeling in so long."

That hug happened around 5 p.m. on August 21, 2022. Twelve hours later, Jon was wheeled into a surgical suite.

There, at Mount Sinai's hospital just southwest of Central Park, surgery team members screwed Jon's head into a frame to hold it still. Then they numbed him and drilled two small holes through the top of his skull, one on each side. Through each hole, a surgeon plunged a long, thin wire dotted at the end with electrodes deep into his brain. The wiring, threaded under his skin, snaked around the outside of Jon's skull and sank down behind his ear. From there, a wire wrapped around to the front, meeting a battery-powered control box that surgeons implanted in his chest, just below his collarbone.

CONTENT WARNING
This story contains discussion of suicide. If you or someone you know is facing a suicidal crisis or emotional distress, call or text the 988 Suicide & Crisis Lifeline at 988.

During the surgery and in the days after, doctors sent small pulses of electricity into Jon's brain. In ways that are still unclear, this electrical tinkering changes the messages that move between different brain regions. The doctors and researchers had what seemed like a bold goal: They wanted these pulses to pull Jon out of the darkness of depression.

Jon is one of dozens of people in the United States currently in clinical trials that aim to heal mental disorders with brain implants. The technique is called deep brain stimulation, and it's built on the scientific premise that electrical stimulation can reset brains that are in the grip of powerful and devastating psychiatric disorders such as depression, obsessive-compulsive disorder and post-traumatic stress disorder.

DBS isn't mainstream, but it's not particularly rare either. The technique was first approved by the U.S. Food and Drug Administration in 1997 to treat tremor, and in 2002 to treat Parkinson's disease. DBS is also used by doctors for severe cases of epilepsy and dystonia, or involuntary muscle contractions. Today, DBS electrodes are in an estimated 244,000 people's brains around the world, most of them there to treat neurological diseases.

DBS's reach is expanding fast, particularly for mental disorders. In 2009, for instance, the FDA granted a humanitarian device exemption for DBS to treat obsessive-compulsive disorder. In small experimental trials, people have been implanted with electrodes for pain, eating disorders, addiction, traumatic brain injuries, PTSD and major depressive disorder — Jon's disease.

For the unsettled science of psychiatric disorders in particular, there are big questions still to be answered: How exactly does DBS change the brain? What do those changes do to a person's sense of self? And, perhaps most important to Jon and others desperate for relief from unrelenting depression, do the brain implants work? Jon's surgery was a last-ditch, desperate maneuver. It was his Hail Mary.

280 million

Estimated number of people worldwide who have major depression

2.8 million

Estimated number of people who have treatment-resistant depression in the United States

Desperate for help

Jon's a sharp, funny middle-aged guy, a self-described "character," who lives in a small town northeast of Philadelphia. He's a dad with three busy kids and a garage packed with hockey sticks, softball catcher pads, golf clubs, balls of all sorts, bikes, in-line skates, a mesh goal and a supercute white motor scooter. He's a coach (hockey and softball) known for dispensing "isms" and the phrase, "I'm going to give you some life advice." He's a husband who worries about his wife doing too much and not taking care of herself. He's in advertising, a people person who used to love having his friends over to hang around his fire pit.

For a decade, Jon let his outgoing personality carry him as he struggled to overcome his depression. His disease, and the suicidal thoughts it forced on him, grew worse in the last five years. On the outside, Jon was the hypersocial, high-functioning guy everyone expected him to be. But inside, his profound depression was a private hell, he says. "I'd be the one standing in front of everybody leading a champagne toast, and then I'd be driving home and wanting to slam my car into a tree."

Jon fantasized about other deaths: a mugging, a plane crash. Until Jon's son asked if he would see Jon again, on the evening before the procedure, Jon even nurtured a little bit of hope that he might die during the brain surgery he volunteered for.

Jon's depression also stole his motivation, leaving him wrung out and isolated from his family. He overate, overslept and drank too much. His worst stretches, he suspects, left his family traumatized. "I had poison in every single bit of my body. It literally ran throughout every cell in my body," Jon says. "My blood carried the poison, and it crushed everything in me."

Melancholia, one of depression's early names, comes from the ancient Greek word for "black bile," a diseased liquid believed to flood a body. It was once thought that bloodletting and other ways to let the corrupting fluids out could ease people's minds. Today, doctors have much better treatment options. Antidepressant drugs and talk therapy can be effective for many people. But not everyone. An estimated 280 million people worldwide have major depression. A subset of that giant number fall into a hopeless-sounding diagnosis: "treatment-resistant depression" or "intractable depression." In the United States, an estimated 2.8 million people have that diagnosis.

Jon is among them. Talk therapy, antidepressants, antipsychotics, ketamine, cannabis, transcranial magnetic stimulation (in which magnetic fields target nerve cells through the skull), several residential treatment stints, even electroconvulsive therapy, which left him with intense memory loss — none of these treatments reliably worked for him.

Amanda, an app and web designer and artist in her 30s who lives in New York City, can also rattle off a long list of therapies she has tried for the deep depression she's felt since she was 13. She has been on 21 different antidepressant drugs. Her brain has been zapped with transcranial magnetic stimulation. She has had IV infusions of ketamine.

Amanda, who to protect her privacy requested her last name not be used, has also had 40 rounds of electroconvulsive therapy, or ECT. The "gold standard" treatment for people who aren't helped by other therapies, ECT is often done several times a week for three or four weeks. For unknown reasons, the resulting miniseizures in the brain can provide relief. "The electroconvulsive therapy helped a little bit," Amanda says. "But for it to help, I had to do it so frequently that I got memory damage."

Jon's depression was poison; Amanda's was a vortex. And when ECT was no longer an option, that vortex nearly consumed her. After a suicide attempt, she spent six weeks in the hospital and then another six weeks receiving outpatient care. "It was at that point that [doctors] were like, 'There's nothing else we can do for you. You've tried literally everything that's out there. If ECT doesn't work, that's it,'" Amanda says.

As with Jon, her doctors had given up, Amanda says. "When you get to that place where they say there's nothing else we can do for you, and yet you have to keep living your life, that's a hard place to get to."

Amanda ultimately found her way to the treatment-resistant depression program at Mount Sinai. As Martijn Figee, a psychiatrist and DBS researcher at the Icahn School of Medicine at Mount Sinai, explained the procedure, research and risks, Amanda listened carefully. She arrived at appointments with an eight-page–long list of questions that covered the practical ("What should I avoid forever once I have it? Running? Hanging my head upside down? Trampolines?") and the profound ("What makes a person want to be alive?"). Questions answered and fully informed, Amanda agreed to have DBS surgery.

Jon heard about the procedure in 2021. He called the Mount Sinai program from a residential treatment facility, only to learn that he didn't qualify because, at the time, he hadn't yet tried ECT. So he did 12 rounds of the therapy in early 2022. ECT didn't help Jon, and the experience shook him. "It was horrific. Zero relief. My memory loss is still pervasive to this day," he says. It was utter misery, but he qualified for the DBS trial.

In the run-up to the surgery, Jon's wife, Barbara, worried about both the surgery and the outcome. "What if they slip or they sneeze and they ruin his brain?" she recalls wondering. "What if it doesn't work? What do we do next?… There's no option of giving up."

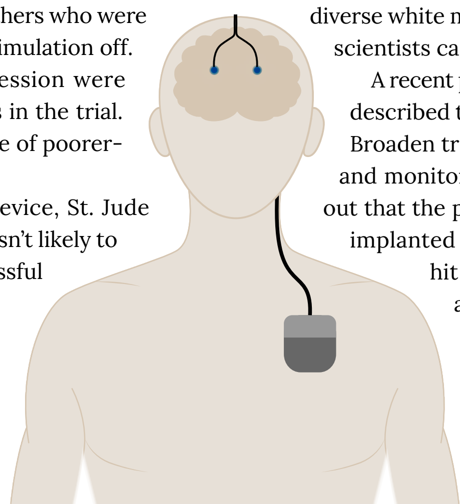
Jon, however, was not worried. "I didn't care that I was having my head cut open," he says. "I had the same level of anxiety that you would have if you were getting your teeth cleaned."

Hitting the right spot

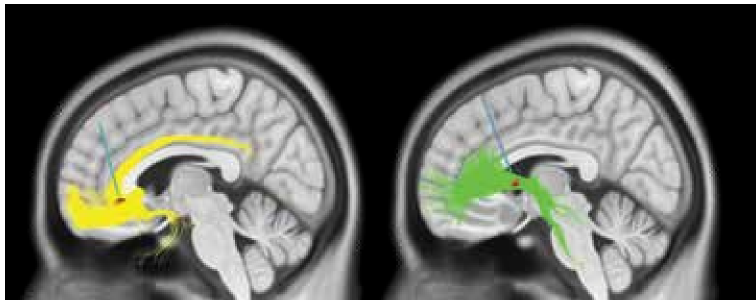
The DBS program that Jon and Amanda are a part of looks vastly different from earlier iterations. In 2008, Helen Mayberg, a neurologist and neuroscientist then at Emory University in Atlanta, and many colleagues around the country had just begun a large, double-blind DBS clinical trial to test the technique in people with severe depression. Called the Broaden trial, the study compared how people fared after six months, some of whom had electrical stimulation on and others who were implanted with electrodes but had the stimulation off.

All told, 90 people with severe depression were implanted with brain stimulation devices in the trial. But in 2013, testing stopped early because of poorer-than-expected results.

The sponsor and maker of the DBS device, St. Jude Medical Inc., determined that the trial wasn't likely to hit its goals. Along with another unsuccessful trial, which included 30 people who received stimulation in a different part of the brain, those lackluster results represented a real setback for DBS as a treatment for depression.



Depression device In deep brain stimulation for depression, electrodes surgically implanted in the brain are connected via wires under the skin to a battery-powered control box in the chest. The programmable control box tells the electrodes when to send signals that stimulate the brain.



Deep brain stimulation for depression changes signals near the electrodes (red) and signals moving along brain fibers called white matter tracts (yellow and green). The subcallosal cingulum (left) and the ventral capsule/ventral striatum (right) are two current targets.

The disappointing findings fueled criticisms of the method, underscored by stories of people who had negative experiences with DBS. And potential conflicts of interest exist, as they do for many medical treatments that depend on medical device companies. Mayberg, who now directs the Nash Family Center for Advanced Circuit Therapeutics at Mount Sinai, for instance, receives fees for consulting and licensing intellectual property from Abbott Laboratories, the company that bought St. Jude Medical.

Despite setbacks and criticism though, the research didn't stop; it matured. Brain-imaging methods got better, allowing researchers to see exactly which highways of white matter fibers, message-sending bundles that emanate from nerve cells, are influenced by the electrodes. Other aspects of care, including follow-up sessions with mental health experts and therapists, have also evolved. In a small DBS trial of 11 people with severe depression, for instance, nine had their symptoms improve, researchers reported in 2018.

Jon and Amanda have been receiving constant brain stimulation targeted to a brain area called the subcallosal cingulate, or SCC. The area is not a uniform glob of tissue. It holds a confluence of diverse white matter tracts, and with better imaging tools, scientists can now see the details much more clearly.

A recent presentation from Mayberg's research group described the outcomes of about 50 patients from the Broaden trial, people who continued to be stimulated and monitored after the trial officially ended. It turns out that the people who got better had their electrodes implanted in a fortuitous spot in the SCC, one that hit four key white matter tracts. "It was really about targeting," Mayberg says.

The SCC — and the signals it sends to other brain areas — seems to have a role in generating negative emotions, immobility, cognitive sluggishness and heavy physical feelings. Stimulating there, researchers suspect, can overwhelm

FROM TOP: S.A. SHETH AND H.S. MAYBERG/*ANNUAL REVIEW OF NEUROSCIENCE* 2023; ERIN OTWELL



Jon Nelson's deep brain stimulation treatment hasn't made him happy all the time. "I guess I'm just a cranky middle-aged dude now," he says of his personality. But he feels as if he is cured; he now enjoys experiences more, including moments like coaching hockey and softball.

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those nerve cells, tiring them out and making them effectively fall silent. That silence then has ripple effects at many different levels, from single cells to entire cohorts of brain areas. Those changes, the thinking goes, somehow turn down the negative malaise. It's a bit like taking off the parking brake, allowing energy and motivation to flow once more.

Mayberg and her colleagues at Mount Sinai aren't the only people conducting trials on DBS for depression, nor is their target the only one under consideration. Another promising target, called the ventral capsule/ventral striatum, or VC/VS, is more involved in feelings of reward. Stimulation there may turn up the positive as opposed to dial down the negative. Its connections to other brain regions are extensive, perhaps even more numerous than the SCC's.

Some of the big questions, says Sameer Sheth, a neurosurgeon and DBS researcher at Baylor College of Medicine in Houston, are about personalizing the technique: Which patients would benefit from which target in the brain and what type of stimulation? The SCC and the VC/VS both seem promising. In a way, the debate mirrors a similar one in DBS for Parkinson's disease, where several brain structures are possible targets. To determine where electrodes should be implanted, doctors now consider factors like how advanced the disease is, whether a patient needs to reduce their medication and if tremor is the main problem.

Sheth (who has received consulting fees from various medical companies, including Boston Scientific and NeuroPace, and has cofounded a neurotechnology company) wants to better understand the neural circuits related to mood. To that end, he and his colleagues are conducting a clinical trial for depression that uses implanted electrodes to listen in on many parts of the brain. The study is designed, in part, to uncover how various types of stimulation, pointed toward various neural spots, affect the brain. Eventually, the team hopes, this knowledge could lead to personalized stimulation — bespoke electrical patterns tailored to each person.

Day of surgery

When I hear stories of DBS research from scientists, it is often written in dry academic terms in scientific journals. It can be hard to follow and devoid of emotion. But when Jon tells me his story, it's the story of his life. Such deeper, more moving stories are often known only to the people who experienced depression and DBS surgery. Four such stories, including Jon's, appear below.

JON'S STORY — Early in the morning on his surgery day, Jon's medical team told him that Mayberg would check in with him just before the procedure began. "Everybody is like, 'Dr. Mayberg is going to come in and give you a pumped-up speech.'"

She didn't disappoint, Jon says. "'All I need you to do is to be present,'" she told him. "She was really adamant about that."

In the middle of the surgery, the medical team woke Jon up from anesthesia. It was a hazy time, but Jon remembers it. "I'm so awake, and I was so myself," he recalls. "Dr. Mayberg is right in your face … and I said, 'Doc, I need to tell you something.' And she was so concerned, like, 'Yes, yes, yes?' And I was like, 'I'm present!'

"I'm just busting her chops, and she's sitting there laughing. But that's how completely normal you are."

The day after surgery, Jon sat with Mayberg and another clinician as they began to turn on and off electrodes, searching for the pattern of stimulation that would influence nerve cells in

the right way and in the right spot. Each time, Mayberg would ask him two key questions: Did he feel like walking his dog? And did he want to have friends over to sit around his fire pit? Jon's wife, Barbara, his dad and a crowd of doctors and researchers watched a video feed of this process from an overflow room.

After trying a series of stimulation patterns and getting "yes" to their questions, the researchers settled on an electrical pattern, and Jon went home. "The next day, bandaged up on my head, I not only took the dog on a walk, I asked my son and my wife to come with me. I enjoyed the walk. I enjoyed the conversation. I enjoyed coming back home. I sat outside and had coffee. It's just surreal."

As we talk, about six months after his surgery, Jon has no doubt about the outcome: "Instantaneously overnight I was healed," he says. "I have been in remission from depression since the moment they turned that on."

AMANDA'S STORY — Amanda, the artist in New York City, had DBS surgery on October 20, 2022. She has trouble describing the immediate change. "Maybe it was like a little spark of energy. I was more chatty. It was easier to talk to people, just because it felt like there was a little something inside pushing."

Her recovery has been incredibly fast. "I left the hospital on a Friday," Amanda recalls. "By Sunday, I could tell it was working. By Wednesday…that's when I got completely better.

"I can't even describe the relief. I've never felt relief so profound in my life," she says. "You get used to living in pain. And when the pain is all of a sudden gone, you're like, 'What is this?'"

Part of her life now includes what she calls "weird experiences" — taking pleasure in things. Candles, for instance. "I never enjoyed smells before. And now I have these candles, and they smell so good. Candles never smelled good before."

EMILY'S STORY — Emily Hollenbeck also lives in New York City and had DBS surgery in 2021, about a year and a half before I spoke with her. When a certain pattern of brain stimulation was turned on during the surgery, she started to think about bacon. "I was tasting the bacon in my mind. I could taste that salt and the fat and the crispiness. I started to feel that sense of hunger."

Her depression had taken away any anticipation of pleasure. "My mouth won't water," she says. "I won't really think about it." With the stimulation, the contrast between disinterest and intense craving was "so immediate and so strong," she says. "That's why it struck me." In the days after the surgery, she also noticed feeling restless, like she wanted to go to the library. "I had these impulses to move, to do things, to enjoy things," she says.

PATIENT 001'S STORY — Patient 001 was the first to undergo the massive brain eavesdropping effort by Sheth and colleagues. He traveled to Houston from New York City, where he was living at the time, and was scheduled for surgery on March 9, 2020. His surgery squeaked through, just days before all nonemergency surgeries were canceled in the area because of the growing COVID-19 pandemic.



Surgeons placed four permanent electrode leads and 10 temporary ones into the brain of Patient 001, a man with severe depression.

During surgery at Baylor St. Luke's Medical Center, Patient 001 was implanted with four electrode wires, two in the SCC and two in the VC/VS. He got 10 extra electrodes, too. These extras were temporary, there only to listen to his brain activity over a 10-day stay in the hospital. "I'm not going to say the 10-day stay in the hospital was a walk in the park, because it wasn't," he says. "But when you have nothing to lose and you're in hell, you'll do anything."

At one point during the electrode-testing phase, Patient 001 felt something big. "I said, 'I don't know what you did, but it feels like I'm online again. I'm online.' If you think of your brain as a computer, it felt like I had a virus, and then my hard drive crashed. And all of a sudden — boom. They control all the leads, and they reboot you, and you're OK again. I remember the doctor and the people in the OR literally laughing, like, 'That's a new one.'

"We laugh about it, but it came out of my heart," he says. "It's how I felt."

Learning to live

Barbara, Jon's wife, has seen the shift from the outside. His motivation is back, she says. He's not as fidgety as he was. He's easier to talk to. He cooks elaborate dinners for the family. He even looks different. When he is sick, Jon has a clammy, pale, almost puffy look to him, Barbara says. "I haven't seen that look in six months, which is amazing. He just looks healthier.

"He has the old Jon voice back. He annoys me more," she says. "He's a super high-energy, outgoing person, and I'm the quiet, withdrawn person who needs more time alone. I'm like, 'Oh my God, would you just stop talking?' That's a good thing, though, that's a good thing, because for a long time, he didn't want to talk at all."

When Barbara and Jon got together in their early 20s, she thought Jon was the happiest and nicest person she had ever met. Now, "the person I met 20-something years ago is back," she says. "I feel like he was lost for a long time."

The stories of Jon and the others all sound remarkable, and in

BAYLOR COLLEGE OF MEDICINE NEUROSURGERY

all sorts of ways, they truly are. These four people with depression were pulled out of deep suffering and restored to themselves—for now, and for what they and the researchers expect will be a very long time. But like any stories, they have their plot twists, including inconveniences and full-on moments of despair.

"The only thing I'll slightly complain about—and it's very vain—I only wish the batteries in your chest didn't show up so much," says Patient 001.

There is an intense physicality to deep brain stimulation for depression. Participants have two slight bumps on their head, wires under the skin of their neck and a battery-powered control unit implanted under the skin in their chest.

Because he was implanted with two sets of electrodes, Patient 001 has two battery packs, one on each side of his upper chest. He lives in a hot place near the ocean. "It just sucks I can't take my shirt off at the beach and not be self-conscious about that," he says. Sometimes the devices in his chest feel alien to him when he's going to sleep. "I put my hand on it to be comfortable."

Amanda has a strained relationship with the device, too. "I don't like the idea of it. I don't like how it feels. Every time I accidentally touch the wire in my neck, I'm like, 'Ugh, ugh, I don't like it,'" she says. "It's getting better, but sometimes I can still feel that thing in my chest just sitting there." She also points out the annoyingly low-tech charging process, which is done with a wireless charger draped around her neck. Her charger shows only 10 percent increments, and the screen is on for only a minute before it locks up, without indicating that the charging is done. "They can get better at that part," she says.

In addition to the charging, there are lots of tasks these volunteers complete as part of the research—surveys, mood ratings, video journals. Twice daily, Amanda clicks what looks like a TV remote at home to collect brain data. "I'm Bluetooth-enabled," she says with a laugh. "I upload from the computer to the server at the hospital." She and others also make regular trips to the lab at Mount Sinai.

These days, Jon takes the train from his house just outside Philadelphia to Mount Sinai so often that he knows exactly which crack in the sidewalk to stand by as he waits for his train at the New Jersey Transit station. On one of his visits to the lab, a mess of scalp electrodes were eavesdropping on his brain. The scientist doing the measurements, neuroscientist Allison Waters, mentioned that his electrode leads were zipping 130 pulses of electricity into his brain per second.

"She just said it off the cuff," Jon says. Later, with his daughter, Jon did the math for a full day, doubling it for each side: "22 million, 500 thousand electrical pulses to my brain," Jon says. "That's what has kept me alive."

During Jon's surgery, Mayberg told him that his only job was to be present. After his incisions healed, he was given a new task: rehabbing his brain. Jon was initially dismissive of the new job. He already felt fantastic, cocky almost, and didn't buy that he needed to work hard on rehab. "In the back of my head, I'm like, 'OK, weirdos. I'm not sick. This is great. I'm good. I got this.'"

But about six weeks after his surgery, everything fell apart. A malaise crept in, and Jon freaked out. "Oh my God, I feel it," he said. "I feel it in my body." He snapped right back into the habits that depression solidified: overeating, sleeping too much and hiding away from his family. "My wife, I'll never forget it, was like, 'Hey, we got an appointment at the school.'" But Jon told her he couldn't make it; he was busy. It was a lie. "I didn't have anything going on," he says.



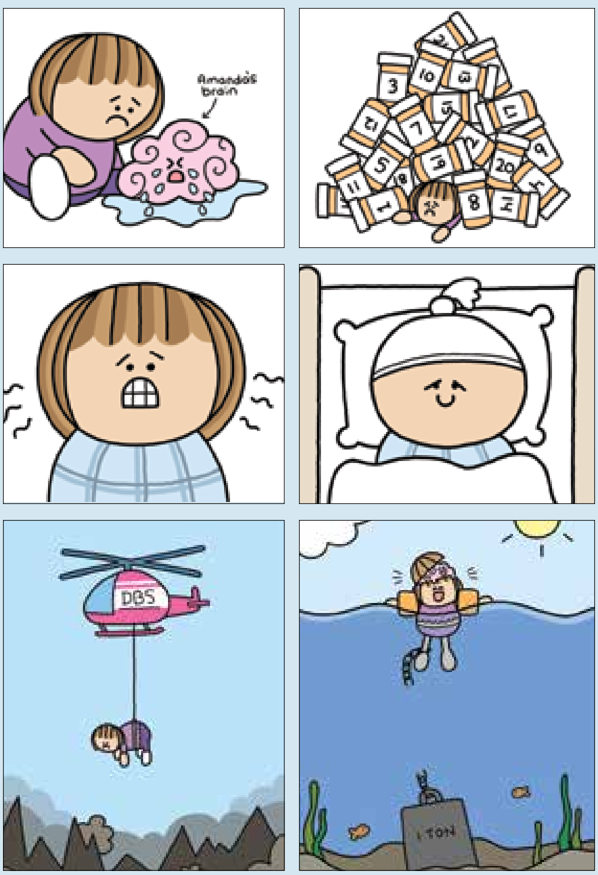
As part of his clinical trial on DBS for depression, Jon Nelson makes frequent trips from his house in Pennsylvania to research labs at Mount Sinai in Manhattan.

AIDAN KAHN



Drawing her depression

"When I was depressed, I didn't want to explore my thoughts," says Amanda, an app and web designer. "Art was sort of like an escape more than a reflection on reality." Amanda's depression started when she was 13. After trying everything — including 21 different antidepressants, transcranial magnetic stimulation, IV infusions of ketamine and electroconvulsive therapy — she received deep brain stimulation surgery in the fall of 2022. A regular character in her art, "cartoon Amanda" depicts her experience with depression and DBS treatment.



Jon knew that as part of the study protocol, around the sixth month, researchers would turn off his stimulation, a looming event that made him intensely anxious. His shift alarmed him so much that on the night of October 6, he sent an email to Figee, the Mount Sinai psychiatrist, to ask if his stimulation had been turned off earlier than planned. "Is there an earlier part of the program where it gets shut off too, such as now, and that is also part of the experiment?" Jon wrote. "Even if it was shut off, could you even tell me that?"

An hour and a half later, the email back was clear: "Your device is absolutely on." His psychologist would address it with him at their next appointment.

As brain implants are used more and more, the risks of DBS have become somewhat clear. Regardless of why a person is getting it or where in the brain it targets, the technique can, like any medical procedure, go sideways. Electrode leads in the brain can break; the chest controller can fail; batteries can die. Infections, in both the head and chest, are a risk, as is wire tethering, a painful condition, also called bowstringing, in which scar tissue grows around the wire in the neck.

DBS can also carry risks that are distinct from other surgeries. Electrical stimulation in certain parts of the brain has been linked to unwanted behavioral changes. For people receiving stimulation for Parkinson's disease, there have been cases of gambling problems and hypersexual behavior.

In one unusual case, a Dutch man who was being treated for obsessive-compulsive disorder developed a brand-new and intense affinity for Johnny Cash hits. When his stimulations diminish or his batteries die, the man subconsciously chooses to listen to his old favorites.

People being treated with DBS for depression have experienced relapses when the device accidentally stops working, for instance due to a battery failure or a wire breaking.

But that's not what happened to Jon.

Worries over spiraling dark moods surface among people with DBS for depression, says psychologist Shannon O'Neill, who works with Jon and other people treated with DBS at Mount Sinai. "We often talk significantly about the difference for them of how they can distinguish between depression and normal everyday sadness," O'Neill says. People who have lived with severe depression for years need to relearn how to recognize and tolerate garden-variety emotions, including sorrow.

As O'Neill describes ordinary sadness, it reminds me of the analogy that emotions are like the weather. We can spend the morning under heavy cloud cover, and then maybe we luck out with a full-blast sunny afternoon. But it's fleeting. Likewise, our feelings are impermanent. "Negative emotions come and go," O'Neill says, "just like positive emotions come and go."

Emily says it took time to recover from her DBS surgery in 2021. "You're letting your brain relearn how to live in the world without the constant threat of severe negativity, suicidality, all of that." She had to learn how to cope with emotions and trust that she'll get through bad situations. "Basically, I'm relearning how to ride the bike, you know?"

PHOTO: BENJAMIN NORMAN

Understanding that these feelings are transitory is something people with severe depression haven't practiced, because they haven't had to. They've been perpetually stuck under heavy cloud cover. Emerging into an emotional landscape with those ups and downs can be intensely unsettling.

"At first it was scary," Amanda says. "At first I felt like I was standing on the edge of a cliff." An artist, Amanda draws her experiences to help her think them through. One of her pictures shows a cartoon Amanda wearing a rainbow shirt, standing high on a ledge of bright green grass with blue sky overhead. But she's looking over the edge to darkness below. "I had been pulled out of this giant pit, and I was worried that I would fall back in it again."

But she hasn't. When people recover from depression with DBS, they generally stay well, several studies suggest. Between three and six years after surgery, about 60 percent of patients had sustained improvements, Mayberg and colleagues reported in 2011. In a longer-term study, reported in 2019, most of a group of 28 people who had DBS for major depression or a type of bipolar disorder saw benefits for more than eight years.

The stigma of depression, and treatment

Like many people who have struggled with a mental illness, Emily had plenty of stories of people not quite getting it. One memorable instance happened as she was about to be anesthetized for an electroconvulsive treatment. The anesthesiologist found out that she had a Ph.D. in psychology. "His eyes settle on me, and he goes, 'Oh, that's ironic.'" Her academic background should have somehow prevented her illness, he seemed to imply. A palpable silence filled the room. "I remember literally biting my tongue," she says, "being like, 'We're not going to sass the guy who's injecting the propofol.'"

Being open about depression can bring judgment, and danger: "If you are honest about what you need for your mental health, you can suffer consequences," Emily says. That can include lost jobs, lost relationships and perhaps most crucially, lost health care. Those consequences are why I'm not identifying Patient 001 by his name. He works in an intensely intellectual and competitive field, and with a new baby at home, he can't risk losing business over people's mistaken assumptions.

There's stigma surrounding depression, and there's stigma surrounding its treatments. When Patient 001 told his family he was getting experimental brain surgery, they didn't understand. "At first, they were like, 'You're crazy. It's unsafe.'"

In a way, their reaction tracks with other treatments for depression, and psychiatric disorders more generally, despite the fact that they work for many people. Since their rise to prominence in the 1990s, antidepressants have caught heat from people claiming the drugs change personalities and steal emotions. Electroconvulsive therapy is still crawling back after the damage done by portrayals like in the movie *One Flew Over the Cuckoo's Nest*. Even talk therapy can bring shame and secrecy.

So perhaps it's not surprising that electrodes implanted into your brain raise a whole new set of assumptions, misgivings and judgments. People will live with these stigmas until society changes, until people start understanding what severe depression is like, and what treatments are like too.

"You're screaming for help, and they just don't understand," Patient 001 tells me. "That's probably one of the reasons I'm talking to you, even though I'm doing it anonymously. I hope one day one kid reads what you're writing, and he finds DBS and he's cured."

Barbara, Jon's wife, is no stranger to people's uncomfortable



External electrodes on a cap measure Jon Nelson's neural signals as part of a research project to see how the brain changes with DBS.

AIDAN KAHN

reactions. "When we have told people that he has a pacemaker in his brain, basically, you get this sort of strange, 'Oh my God.'… They're like, 'What? You're going to let them do this to you?'" There's this assumption, she says, that the brain is somehow different from other parts of the body. The heart can also need a device that delivers electrical stimulation. So why not the brain? "It's really interesting to see people, myself included, process that."

The idea of a machine forcing happiness on us or taking away sorrow — that kind of mind control is unsettling for most of us. We are fiercely protective of the idea that our feelings originate inside of ourselves, that we are in charge here. Brain implants that ease tremors in people with Parkinson's don't seem so troubling. But the questions get stickier when it comes to our emotions. The idea that artificial happiness can be created by a computer that controls electrodes in our brain hooked to wires that snake down our neck? No thanks.

That sentiment is understandable, but it's not what people with these implants experience. As I've talked with people who had lived first with devastating depression and then with these devices, I have come to think that these implants do not make a person feel artificial joy. "DBS is not going to give you happiness," O'Neill says. Instead, "it just kind of clears the way."

Reporting this story, I also heard a lot of jokes about being a cyborg, Bluetooth-enabled, bionic. Was there anything to these offhand comments? Even if the brain implants don't control you, do they change who you are? Jon kindly tells me that he understands why I'd ask. "I can only tell you that it is the exact opposite of that question," he says. For him, DBS took away his poison. "It purely eliminates the disease.… That's it."



Barbara and Jon Nelson are shown here in the first picture they took together. Barbara says Jon's depression "probably shaped so much of who I am and how I am now in so many ways."

Amanda echoes the sentiment: "Nothing I've ever done has changed who I am or my personality," she says, DBS included. "I'm still the same person. I'm just suffering more or less."

Emily flips my question on me: "What does that even mean? Where is the 'me'?" Equating ourselves with our brains makes sense, she says, because much of what we experience comes through our brains. "But is that really where our selves are?"

Who she is, Emily says, is an activity, a choice. Her depression took away those choices and altered who she was. But now, "I don't have that feeling, so which of those is correct? I don't know. But I know which one I like better. I know that's not a satisfactory answer for your question, but what really gets to the heart of it is that I feel like I'm untethered, and I have the ability now to focus on the things that I do really care about. And that's where my self lies."

These days, Jon says, his sense of self is lighter. Without the poison coursing through his body, Jon feels better, more energized, more present in his life with Barbara, their three kids, a dog, a cat and a bearded dragon named Lizzy. But, as his daily surveys make absolutely clear, he's still crabby. "There are certain things that you realize are the disease, and certain things that are innate in who you are," he says. His irritability scores didn't budge after DBS. "I guess I'm just a cranky middle-aged dude now."

Barbara may be one of the best judges of who Jon is now. Is he different somehow with DBS and without severe depression? "I don't feel like he's changed," Barbara says. "I don't feel like I have a different person living in my house. It's not that creepy, sci-fi way, like there's this new person." It's just him, the Jon she met all those years ago.

What's next?

Despite stories from Jon and others, deep brain stimulation still has its stigma to overcome, even in the research world. Questions of autonomy — of control over feelings and actions — crop up in ethics discussions of brain technology. But to Figee, those questions are a "luxury problem." That framing ignores the idea that mental illness itself takes away a person's control. "People who work in DBS are always a little frustrated by these discussions," Figee says. "We're always like, 'Talk to the patients.'"

Figee, who receives consulting fees from Medtronic, a device company that makes brain implants, and his colleagues have asked people before and after surgery for DBS for obsessive-compulsive disorder and Parkinson's about their feelings of being in control of themselves. People did not report a loss of feeling in control after the procedure. In fact, the people treated for OCD reported a bigger jump in autonomy and control than the Parkinson's patients. "The OCD was more of a prison to them than the fact that they have this implant," Figee says.

O'Neill says she hopes that the procedure will be more readily understood in the future. "What I'd love is a shift toward not making it a last resort," she says. "I wonder if we wait too long to give an individual DBS." She doesn't mean that brain implants would be an early treatment, but instead, she wants other health care professionals to have more awareness of the procedure so that they can refer people who have run out of hope.

When I ask Mayberg what's next for DBS, she cringes at the slow pace of the research. Her first paper describing DBS for depression in the subcallosal cingulate (then called Brodmann Area 25) appeared in the journal *Neuron* in 2005. Almost 20 years later, she almost can't believe that researchers are not further along in bringing this technique to people who would benefit from it. A lot has been learned, but she feels impatient. "We don't have a lot of time," she says. "People are dying now, so let's fix them. And then we can make something better."

COURTESY OF J. NELSON



After DBS surgery, Jon has been able to be more present with his wife and three kids.

AIDAN KAHN

Mayberg hopes to see the treatment become streamlined. The first heart pacemaker was an incredible piece of technology, but it was giant and clunky. Today, the powerful device, usually about the size of a matchbook, sits near millions of people's hearts, keeping them beating. Similarly, Mayberg wants to take today's complicated DBS technology to simpler versions.

"What's the future of this, the future three steps ahead?" asks Mayberg. "I have no idea."

It will almost certainly include nuanced and complex science. Jon and Amanda are participating in follow-up studies searching for signs of recovery in their brains, bodies and microexpressions on their faces, and even in their voices. Jon spends eight minutes twice a day recording his brain waves, along with video journaling and daily, weekly and monthly surveys. His brain is imaged regularly.

Researchers are searching for a hallmark, a signature, that can tell them the method is working. "I need to have a way to discriminate," Mayberg says. "When are you having a bad day and when are you relapsing? Those are not the same thing." Mayberg and her colleagues have some hints and are hoping to publish the results soon.

A handful of trials are putting a spin on the typical DBS approach and studying what's called adaptive DBS, which kicks in only when a certain pathological brain activity pattern is detected. That approach has worked well for a woman named Sarah with severe depression. Researchers at the University of California, San Francisco published the details of her improvements in 2021 (*SN: 11/6/21, p. 7*).

Similar on-demand efforts are happening for other disorders, including binge eating and PTSD. Jay Gill, a brain researcher and medical student at UCLA, told me that one man, a veteran with PTSD, described having an aura, a sort of premonition, just before his symptoms would get bad. With his adaptive DBS system in place, he still gets triggered and feels the aura, but instead of feeling worse, a feeling of calm sets in.

The optimal DBS approach for depression may be similar to the approach for PTSD, OCD, addiction and other psychiatric disorders. Or maybe not. There's still so much to learn.

Not everyone thinks about depression, or any illness for that matter, as a battle. Jon does. And today, he no longer feels like he is losing it. The Nelsons are hopeful for a future that's better than the past. These days, their house is bright. It's full of laughter, riddles, good-natured teasing, homemade pizza — and an energetic kid on in-line skates who twirls and glides through the kitchen loop. That makes me reluctant to ask Barbara a question that I know will be hard for her to answer: Is she worried that Jon's DBS treatment will stop working?

"That's always in the back of my mind a little bit," she tells me. Over the years, Barbara has learned to temper her expectations for the future. "You just never really know what's going to happen," she says. "But my perspective is that even if something changes, we have had this time with him.… And if it keeps going forever, that's amazing. It's amazing. I hope it does."

Watch Jon, Barbara and Amanda describe their DBS experiences in their own words at bit.ly/SN_brainimplants

On the drives home from softball, field hockey, golf, basketball and ice hockey, Jon and whichever kids are around have chats, what Jon calls "car talk with the kids." In one of these car talks, Jon's youngest piped up. "He's like, 'Dad, I'm so happy you just kept fighting for us.' These little comments that come out of nowhere. I'm like, 'Oh my God. They get it. They understand it.' It's a trip." ■

Explore more

- Sameer A. Sheth and Helen S. Mayberg. "Deep brain stimulation for obsessive-compulsive disorder and depression." *Annual Review of Neuroscience*. July 23, 2023.

A new view of animal behavior



KAYLEIGH MCCOLLUM

UNSUNG CHARACTERS

This article is part of a *Science News* series highlighting people of science — past and present — who we believe should be better known. Watch for more of these stories, and send your ideas to editors@sciencenews.org

Ambika Kamath and Melina Packer are working to overturn biased, outdated views in biology

By Darren Incorvaia

Evolutionary biologist Ambika Kamath, left, and social scientist Melina Packer of the University of Colorado Boulder are working to dismantle outdated, biased scientific ideas through research and a new curriculum.

When Ambika Kamath was a graduate student in evolutionary biology at Harvard University, she knew one thing for sure: She wasn't going to research anoles, the lizards that her adviser, Jonathan Losos, specialized in. "I started out as one of those rebellious renegades," Kamath says.

She went to India for a couple of years to study the poorly understood fan-throated lizards instead. But in trying to map their territories, she found chaos. "All of the lizards were moving everywhere," she says.

Losos encouraged her to work with anoles after all. It was well established that males hold individual territories that they protect from other males, and females mate with only the male whose territory they reside in. Studying how the details of territoriality differed across habitat types, like forests and parks, would be more straightforward.

So Kamath went to Florida, where she identified and tracked individual anoles day in, day out. Kamath studied the anoles "in a larger area, in a longer period of time than anyone else had ever done," says Losos, now at Washington University in St. Louis. But instead of revealing territorial differences, this massive dataset showed that the anoles weren't territorial in the first place.

Kamath looked into the historical record to see where the idea originated. It started with a 1933 paper that described frequent sexual behavior between male lizards in the lab. The authors had concluded that this behavior must be "prevented by something" in the wild, Kamath says, which they inferred was the males protecting territories. "The very first conclusion," she says, "was based on a homophobic response to observing male-male copulation." Later researchers assumed the shaky conclusion to be true.

With this work, Kamath had entered the world of scholarship aimed at critically examining science, including who is doing research and what biases and viewpoints they bring to it. In particular, Kamath has adopted a feminist approach to

science, which critically examines not only how women and gender minorities have been excluded, but also how sexist and gendered ideas have influenced scientists' questions and findings — whether they know it or not. Incorporating diverse viewpoints and dismantling old ways of thinking can "give rise to a new science that is more humane, and that recognizes the perspectives of women and people of color as valuable," biologist Zuleyma Tang-Martínez, widely recognized for her research challenging accepted paradigms, wrote in 1992.

Human bias shapes science

Kamath's research led to a collaboration with another evolutionary biologist, Max Lambert. In 2019 in *Nature Ecology & Evolution*, Lambert, Kamath and colleagues argued that sexual behavior probably first evolved to be indiscriminate to all sexes. Given how common same-sex behavior is in animals, the prevailing hypothesis that exclusive heterosexual behavior is the baseline from which same-sex behavior evolved doesn't make sense, they proposed.

The focus on explaining homosexual behavior, Kamath says, is "driven by these heteronormative, if not homophobic, assumptions that are baked into the science." If we remove those assumptions, "we're going to actually reveal a lot more about biology."

In another example, Lambert teamed up with social scientist Melina Packer, then a graduate student at the University of California, Berkeley, to critique the gendered terminology and thinking that dominated environmental toxicology. Research since the 1990s had focused on chemicals that scientists feared caused frogs to unnaturally switch sex, using terms like "feminize" and "demasculinize," but Packer and Lambert found that this worry was overblown.

In fact, frogs switch sex all the time, for all sorts of reasons, and sex changes don't result in population declines. "If you go into an experiment assuming that chemicals are causing sex changes, then you're going to find it," Packer says. What seems unnatural to humans is perfectly normal in frogs.

A new curriculum

Kamath continues to challenge biological ideas that are rooted in human bias, now at her own lab at the University of Colorado Boulder. Her group, which includes Packer, focuses on understanding how animals interact with each other and their environments, while also examining how human identities and biases shape our perceptions of animal behavior. She calls her lab the Feminist Lenses for Animal Interaction Research, or F.L.A.I.R., Lab.



After tracking the movements of brown anole lizards (*Anolis sagrei*), Ambika Kamath discovered that what scientists thought they knew about the lizards' territoriality was based on bias, not evidence.

"Feminist critiques of science have been going on for decades," Packer says. Yet few scientists are ever exposed to social studies that look at science as a human endeavor, complete with human biases.

Kamath and Packer are working to change that with a new course in animal behavior that is critical and cross-disciplinary. Some students are surprised by the feminist critiques in the course, and some push back against the approach. "If we want this more expansive view of doing biology to take root, we're going to have to face that friction," Kamath says. She and Packer are also writing a book that builds feminist frameworks for understanding animal behavior for a general audience.

Kamath and Packer are both early-career scientists; redesigning a curriculum and writing popular science books aren't typical activities among their peers. "That's particularly brave at this career stage," says Lambert, now a biologist at the Washington Department of Fish & Wildlife, "to be planting your flag on what you care most about."

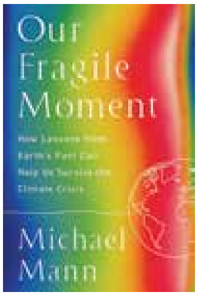
And though Losos says he and Kamath have many differing views, they have never gotten in the way of work. "She has certainly opened my eyes to things that I really never used to think about," Losos says.

Kamath and Packer recognize both the challenges and stakes in what they're doing. Given the recent flurry of homophobic and anti-trans legislation, says Packer, "it doesn't help if scientists are reinforcing those same kinds of assumptions," even unintentionally. Papers questioning leading scientific paradigms often struggle to be published, Kamath says. "How much biological discovery are we missing out on?" she asks. "If you have the ability to start changing the conversation, even within scientific communities, it's an important part of the process." ■

Explore more

- Learn more about the F.L.A.I.R. Lab by visiting kamathlab.com

Darren Incorvaia is a freelance writer based in the Bay Area of California.



Our Fragile Moment
Michael Mann
PUBLICAFFAIRS, $30

BOOKSHELF

Finding modern lessons in Earth's history of climate change

Over four millennia ago, in the final days of the Akkadian Empire in Mesopotamia, a drought swept over the region, afflicting lands as far away as Greece and what's now Pakistan. Probably driven by the eruption of a distant volcano, the drying climate devastated local agriculture. A contemporary text, *The Curse of Akkad*, noted that "the large arable tracts yielded no grain…the irrigated orchards yielded no syrup or wine, thick clouds did not rain."

As once-prosperous farmlands collapsed in the northern part of the empire, people fled to the south. The southern Akkadians' response? Build a more than 150-kilometer-long wall between the Tigris and Euphrates rivers, barring entry to any migrants. Soon after, history's first empire crumbled, dying of thirst in the cradle of civilization.

Both climate systems and civilizations are stable only up to a point. In *Our Fragile Moment*, climate scientist Michael Mann reminds us that today we are pushing the limits of both.

In the book, Mann looks back at episodes of global climate change over the last 4.5 billion years, from eras of deadly heat to wastelands of widespread ice. With each instance, he draws out lessons about what happens to Earth in periods of changing climate. Sometimes, the result is dramatic mass extinctions or geologic upheavals. Other times, as with the Akkadians, it's societal collapse.

Earth's climate system includes regulating forces that tend to buffer against small shifts in climate; ice caps and low clouds reflect sunlight and help cool the planet, for instance. But pushed too far, regulating forces can be overwhelmed, causing the climate to spiral out of control.



Human-caused global warming threatens one of Earth's natural climate regulators — glaciers (a glacier in Argentina, shown).

CAVAN IMAGES/GETTY IMAGES

This was the case 55 million years ago. As a steady set of volcanic eruptions spewed carbon dioxide into the air, Earth warmed. The heat may have contributed to thinner and less reflective clouds. This in turn would have made the planet even hotter. Eventually, the low-lying clouds disappeared, and average global temperatures soared to 32° Celsius (90° Fahrenheit) in what is referred to as a Hothouse Earth.

Today, with unchecked greenhouse gas emissions, we may face a similar, though less sweltering, spiral with the disappearance of our reflective ice caps.

But what makes current climate change different is its source — humankind — and our ability to stop it. This is a benefit that is unique to our changing climate. It comes with blame, but it also comes with agency.

That agency is an important source of hope for Mann. Melting ice caps could raise sea levels and displace some 40 percent of the global population. Rising heat could make swaths of the planet uninhabitable. But if we act, we can preserve a world that looks much like ours. The limit is not geologic or even technological, Mann argues; it is political.

Despite the far-reaching themes Mann weaves throughout the book, it may not be for everyone. There is a strong academic bend to the writing, which leans heavily on jargon. The book also features a dizzying parade of researchers, and Mann often emphasizes his connection to climate researchers and events, at one point reminiscing about how he "was known as a bit of a statistics guru." The technical terms, acronyms, initialisms and self-referential tangents can distract from the book's broader arguments and message.

Even though Mann's dedication to precise academic language comes at the expense of some clarity, climate buffs will appreciate the deep dives into the scientific process. Many of the dense sections reward the reader with a satisfying tidbit of fascinating information or an illuminating insight. On occasion, I laughed out loud at Mann's puns, jokes and barbs. (A reference to *The Princess Bride*'s ROUSs — Rodents of Unusual Size — landed particularly well.)

After journeying through the past, Mann brings us to the present and looks toward the future. Though past climates may offer lessons, those lessons only go so far. We are unlikely to bring about another Hothouse Earth, but the climate is warming faster than it has in millennia, thanks to human actions. If current climate policy holds, the best scientific predictions show things will be painful, but civilization won't end. But climate scientists are not oracles. They can't be sure. That uncertainty, rather than being a cause for complacency, should spur us to action, Mann argues.

"The impacts of climate change, no doubt, constitute an existential threat if we fail to act," Mann concludes. "But we *can* act. Our fragile moment can still be preserved."
— Luis Melecio-Zambrano

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Be Loud Studios creates unique opportunities for students to write, record and mix their own radio segments and podcasts. Based in New Orleans, the nonprofit organization builds students' confidence through radio and digital media production. The aim is to encourage students to not only be consumers and listeners but also creators.

Now in its third year as part of Society for Science's STEM Action Grant program, Be Loud Studios recently received a $10,000 grant from the Society to help young people develop valuable skills, as well as to build platforms for students to find and share their voices.

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AUGUST 12, 2023

More than words

The James Webb Space Telescope, or JWST, has been a big success, thanks in large part to senior project scientist Jane Rigby, who is also an advocate for LGBTQ+ astronomers, ***Lisa Grossman*** *reported in "The telescope whisperer"* (SN: 8/12/23, p. 24).

"Thank you for including the article on Jane Rigby.... She is clearly an outstanding scientist, a leader in her field and certainly deserves the recognition this article gave her," reader **Dorothy Tepper** wrote. "The only way this article came up short was that there are no photographs of her actually doing any science.... I would have liked to see photos of her at work; for example, using a telescope, designing or working on equipment, leading a meeting of scientists or engineers or giving a keynote address at an important meeting. Photographs of female scientists actually doing science or engineering work are important for female students and young scientists to see so they have strong role models. I would appreciate it very much if you keep this suggestion in mind for future articles featuring female scientists."

Far out

JWST has discovered many distant galaxies dating to the early universe that are bigger, brighter and more mature than expected, ***Lisa Grossman*** *reported in "Extravagance of early galaxies"* (SN: 8/12/23, p. 18).

Astrophysicist **Brant Robertson** and colleagues analyzed four early galaxies detected by a project called the JWST Advanced Deep Extragalactic Survey, or JADES, **Grossman** reported.

Astrophysicist **Cosmin Ilie** of Colgate University in Hamilton, N.Y., wrote that three of those four objects may instead be stars powered by dark matter, not galaxies. **Ilie** and his team published their findings in the July 25 *Proceedings of the National Academy of Sciences*.

Science News covered that study in "Have 'dark stars' come into view?" (SN: 8/26/23, p. 8). The scientists ran computer simulations of how much light a potential dark star might emit at various wavelengths. The team compared those simulated patterns with the objects' photometry — how bright the objects appear in JWST images using different filters — and found three of the objects to be consistent with the dark star patterns.

These dark stars are still hypothetical, and some scientists are skeptical. **Robertson**, of the University of California, Santa Cruz, contends that the four objects are indeed galaxies. To identify the objects as dark stars, it's important to compare the simulated patterns with not only the photometry, but also the spectroscopy of the objects, which yields a more precise analysis, he says. Spectroscopy sifts light coming directly from the objects into much finer wavelengths, similar to how passing sunlight through a prism creates a rainbow. **Robertson** says his team looked at both the photometry and spectra of the four objects and found that each were consistent with the known photometry and spectra of galaxies.

Space time

Glowing cosmic clouds show that the dormant supermassive black hole at the Milky Way's center suddenly brightened and let out a brief pulse of X-rays roughly 200 years ago, ***Lisa Grossman*** *reported in "The Milky Way's heart raced about 200 years ago"* (SN: 8/12/23, p. 4).

Given that the Milky Way's center is about 26,000 light-years away from Earth, reader **Jerry Kreuscher** wondered how scientists could know about an event that happened there 200 years ago.

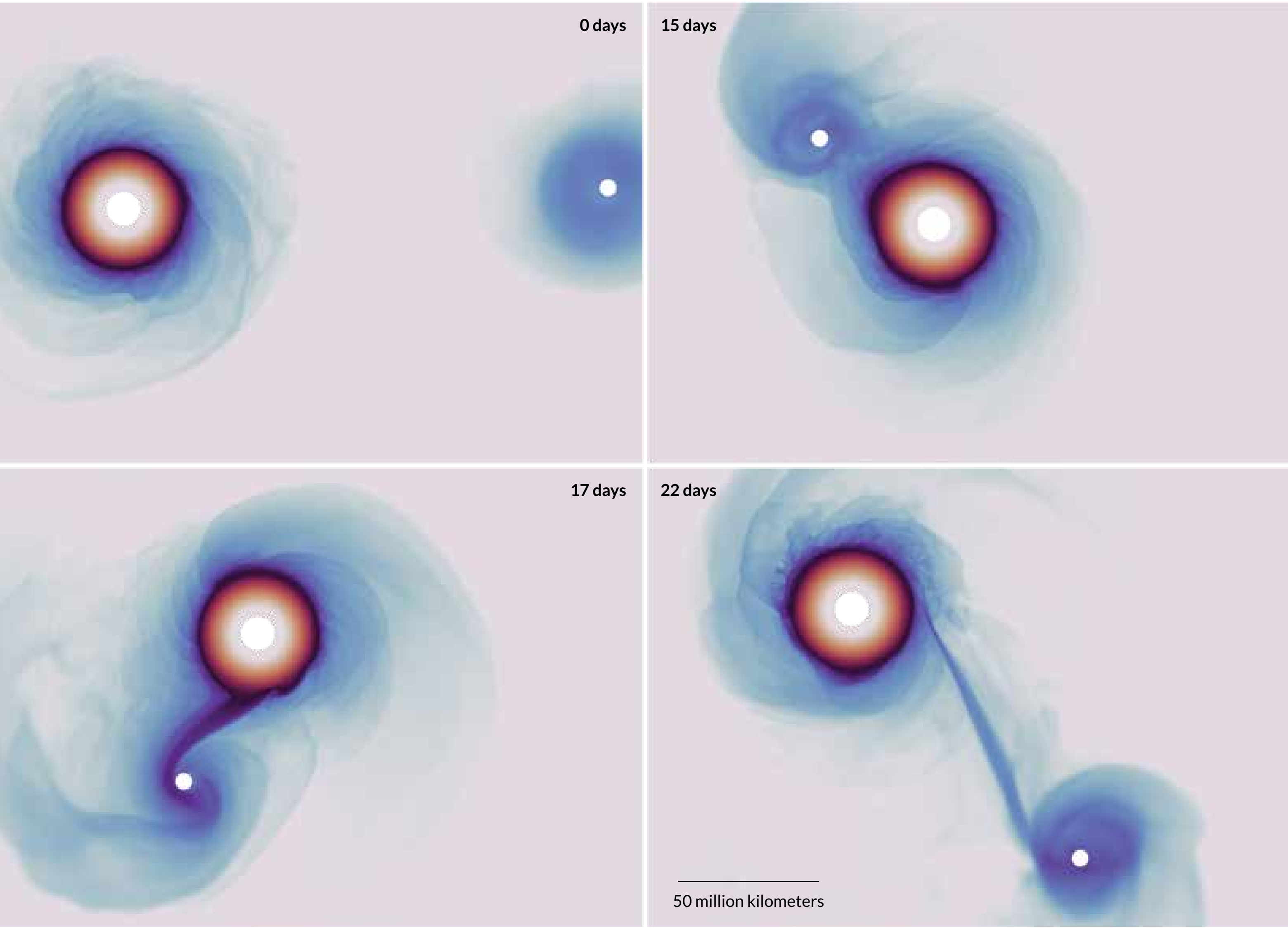
The story described the event as observed from Earth, says associate news editor **Christopher Crockett**, who holds a Ph.D. in astronomy. So "200 years ago" really means about 26,200 years ago in real time. "Writing about space is tricky," **Crockett** says. "Every event has a built-in delay due to light's speed limit. Astronomers themselves often talk in terms of when cosmic events were observed on Earth since the delay is implied (or, in some cases, not known)." But it's true: We don't know what happened to the Milky Way's heart 200 years ago. We won't know for roughly another 25,800 years, **Crockett** says. "With any luck, *Science News* will be around to cover it."

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M. MACLEOD AND A. LOEB/*NATURE ASTRONOMY* 2023

Extreme tidal waves rock a far-off star

Like ocean surf on a beach, enormous waves of plasma may be crashing onto the surface of one massive star.

The star is one of a pair, stretched by the gravity of its companion. That gravitational tug-of-war causes the star's brightness to change drastically and rhythmically. Computer simulations suggest the stretching is so extreme that giant tidal waves undulate and break on the star's surface, researchers report August 10 in *Nature Astronomy*.

The star system sits about 160,000 light-years from Earth. It hosts one visible star that is 35 times the mass of the sun and another unseen star of at least 10 solar masses. The brightness of the visible star oscillates by about 20 percent each month — far more than the roughly tenth of a percent typically seen in pairs of stars whose light oscillates in a similar way.

To explore how the stars respond to such extreme dynamics, astrophysicists Morgan MacLeod and Avi Loeb of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., ran computer simulations of how plasma from the stars sloshes around as they orbit each other.

At the start of one orbit (top left), plasma (blue) swirls around the bigger star (bounded by black; white circle denotes its core) and its companion (smaller white circle). When the stars pass near each other (top right), a tidal wave of plasma rises up on the larger star (at the star's 10 o'clock position). The tidal wave eventually breaks, hurling debris into the larger star's atmosphere. The smaller star siphons some of that plasma off its partner (bottom left). The siphoned plasma feeds a disk around the smaller star (bottom right), turbulence churns up the larger star's atmosphere, and the cycle begins again.

As the waves crash, energy is lost. That could explain why the stars' orbits appear to be shrinking, the study suggests. Eventually, the pair might collide and merge. — *Liz Kruesi*